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EDITORIAL.

THE CLEVERNESS OF MR. ARNOLD BENNETT.

It happens, every now and then, that a literary man with no affiliations with medicine writes so well and instructively on subjects that have been clumsily handled by medical men, that we are safe in allowing ourselves to be guided by him in the maze of doubts and questionings, which the superficiality of the age has dubbed "modern life." Now, if the truth were fully stated, those searching questions would be found to be of a ripe old age, if not of an antiquity that dates back many centuries; for every period in the upbuilding of our civilization has had to contend with what it was pleased to call "the modern spirit that takes but small account of life." Why the modern spirit should be a bugbear to the conservatives in a community needs no further explanation here other than the statement that to them anything that breathes, even the slightest degree of progress, is viewed with misgivings; but conjoined with these are many others who, while their interests lie in the line of progress, are nevertheless at times reminded, by the small voice which is supposed to represent their conscience, that perhaps in dedicating their lives to the spirit of modernity they are living the life that must surely end in a wreckage of nerves and a disheartening deterioration of a number of their internal organs. These ideas have been dwelt upon in detail in all our medical journals, and while the advice in some instances has been excellent, in others—and now we mean the great majority—there has been that absence of largeness of view and kindly philosophy without which all writings lose in effectiveness. Hence, it is with gratitude that we regard Mr. Arnold Bennett's lately published books, "How to Live on 24 Hours a Day" and "The Human Machine."

Imprimis, it would be well to remark that Mr. Bennett is not an opponent of the modern spirit as it has influenced life at the present day, but an ardent admirer, inasmuch as his attitude is one of non-belligerent acceptance of the social conditions as they are. To meet these in a frame of mind that shall be productive of good for others, he has devised a simple philosophy which it would be well for all medical men to read and re-read until they know every word of it by rote. And in its simplicity lies its appeal, as well as in its rationalism: two qualities, we take it, which, though looked at askance by those who delight in burdening their minds with complicated theories and thought-destroying technicalities, have a high value if the desire is to arrive at some goal on the broad highway of clear thought.

By reducing the human organism to what superlative critics might deem a degrading level—namely, a machine, Mr. Bennett, already on the first page of "The Human Machine," illustrates that his mind has enough practicalness to make his definition fit in with this matter-of-fact age. Physicians in recent times have been influenced to no inappreciable degree by the teachings of expositors of the mind in all its ramifications, and the result has been that a cult has been set up in the province of medicine that has relegated to a secondary place the lesser physiology of the body. Mr. Bennett, while not an adept in physiology, is fully aware that the mechanism of the body is on lines similar to those of any other piece of machinery, and that its proper working capacity can only be maintained when a sanity, that is capable of meeting all emergencies, is ready to hand to combat vagaries that act as clogs. This is the fundamental idea of both books, and as such is worthy of more than passing notice; for though we may say that the idea of comparing the human organism to a piece of machinery is trite, the elaboration of it as written by Mr. Bennett must be admitted as new, since it cannot fail to bring home to all physicians the realization of their own flounderings in their futile attempts to direct mankind towards health.

THE DICKENS STAMP.

Those physicians who concern themselves with centenaries should pay particular attention to the one-hundredth anniversary of Dickens' birth, which will take place next year, for the stamps which will be sold will serve a twofold purpose—namely, the proceeds will be devoted to a good cause—the support of the author's grandchildren—and the stamps themselves will be decorative enough to enhance the value of the works

of Charles Dickens, which we take for granted every well-read physician has in his library. It has been remarked more than once in certain medical quarters, that Dickens was no friend of the medical profession, that his characterizations of medical men and nurses are such decided caricatures that truth is absolutely scorned, that humor should be condemned that can only find its best play in exaggeration. While all this cannot be denied, the fact must not be overlooked that humor, no matter how wide of the truth it is, never has the sting of satire, and on account of an inherent kindliness brings forth a laugh even when our Achilles heels are touched none too lightly. Dickens, with his unquenchable humor, is in this respect a much better literary companion than Thackeray, for where the latter makes us smart under his mordant blows, the former merely makes us cognizant of our foibles and teaches us how ridiculous they are. Such correction of our failings should be most welcome, for from so wholesome a lesson must come beneficial results; and if to-day there are those in the ranks of medicine, who take umbrage at what this extraordinarily gifted man said about certain defects which will always be more or less linked to the practice of medicine, so long as human nature is not perfect, more's the pity that the sense of humor should be so limited.

But it is not our intention here to argue for or against Dickens' conception of the physicians of his day, nor the nurses and medical students who came within his ken. But what should be remembered, and not in malice, is the keenness of his eye that detected those very flaws in our social science which to-day, that is some sixty-nine years after the publication of "American Notes" and "Martin Chuzzlewit," are being inveighed against by physicians as menaces against the health of the American nation. Our forefathers, it will be remembered by all those who have followed literary criticism in this country, were highly incensed when this keen eye dwelt in "Martin Chuzzlewit" on the barbaric noises which greeted Martin on his arrival in New York,—noises which, just as to-day in all our American cities, emanated from ubiquitous newsboys to add to the general turmoil,—and for which only very recently a society has been organized in New York for the suppression of city noises, and when, as in "American Notes," there was drastic criticism of the common drinking cup, the habit of expectorating which at times amounted to a deluge, the jack-towel still seen in the lavatories of our best restaurants, and the public comb and hair-brush which were "hanging up before a little looking-glass in the bar, in the immediate vicinity of the bread and cheese and biscuits." Of course, we of to-day have only pity for the shortsightedness of our easy-going forebears who thought

altogether too lightly of the despicable habit of spitting where'er they willed, of the common drinking cup, the public hair-brush, and the common tooth-brush! But have we realized all these reforms? and, if we have, why do we continue to put up in our street-cars such signs as "Gentlemen are requested not to spit on the floor," which is certainly a rare bit of unconscious humor.

When a critic is so acute and withal so kindly as was Dickens, there should be no reason why, when the opportunity presents itself, the medical men of this country should not join with other admirers in showing their appreciation of genius. It does not happen any too often that, after many years, criticisms which once were bitterly fought come true; and since what Dickens once wrote about us, and which was condemned, is now the prime mover in the war which medical men are waging against certain deplorable lacunæ in our civilization, is it not fit for us to recognize his prescience in proper form? But even if this English master of the novel had failed to see our defects, his compositions should make strong appeal, since no physician, wearied after his day's work, can get a better tonic for his nerves than a perusal of pages that declare the imperishableness of the gift of humor.

THE AUTOMOBILE AND THE SEXUAL POWERS.

The criticisms, which have hitherto been visited on the automobile, have been of such a nature that but scant attention was paid them, for what did the enthusiastic chauffeur care whether he was the carrier of germs to the bedside of a patient, or whether in the course of years the contour of his face would betray that too much concentration on the guiding of his car had resulted in a new cast of countenance. But an altogether different phase is put upon the matter by an article in the *Zeitschrift fuer Urologie* (Vol. V., No. 4), in which Professor von Notthafft shows that impotence is the price paid by all chauffeurs, be they medical or otherwise, who are never in a happy frame of mind unless they are driving their cars at top-speed. To substantiate his theory that the nervous system of the chauffeur is severely "damaged," Professor von Notthafft cites five cases which illustrate, beyond a doubt, that the sexual organs suffer in no mistakable fashion from the upset which results from concentration and fear of accident on the part of the chauffeur. The impotence in the Professor's cases was only of temporary duration, though at a certain stage in the treatment the outlook was far

from promising, inasmuch as yohimbin and faradization had failed to bring about good results. Then the possibility of the nefarious work of the automobile occurred to this ingenious investigator; and that his mental attitude was not one of prejudice against the automobile was proved by the complete restoration to sexual prowess of all his patients shortly after they ceased driving their cars. And to prove his contention, so that no critic can arise to show that it is not faultless, Professor von Notthafft gravely adds that those who merely ride in automobiles are not similarly affected, since their sexual powers are considerably increased!

Now, if what is so graphically described by the writer is true, we have at least a partial solution of the vexed question as to why the population in most countries is decreasing. Statisticians have delved deep into this subject with a patience that should halo their heads; but though they have dwelt most alluringly on the subject of the high price of commodities and the unwillingness of families to be burdened with more than one child, as the only reasons for the decrease, their cleverness at finding out the real cause must be called into question. If they really were aware of the cause, as has just been told us by the German professor, they should not have withheld their knowledge from us; for by being the opposite of candid they have allowed nations to diminish in numbers, when by placing an embargo on speed-mania, not only could they have prevented national deterioration, but they could have added to the world's happiness by a ready solution that would have stopped the avalanche of reasons, which has latterly inundated us. For there is France, with a population that is fast dwindling to small proportions, if we are to believe the vital statistics just published in the *Journal Officiel*, and which proclaimed that in 1910 the excess of births over deaths was only 70,581, as compared with 84,061 in the previous year. As is well known, in no country in the world is speed-mania so prevalent as in France; hence, Dr. Bertillon, who has been working for years most assiduously on the subject of why his unhappy country is still cursed with a diminishing birth-rate, and who is no nearer a solution than he was when he began his investigations, should not think too lightly of Professor von Notthafft's timely warning. To save a nation has never been effected save by martyrdom, but in this case the process cannot possibly inflict on the reformer any such inconvenience to life.

THE AVERAGE MEDICAL INCOME.

It would appear from the number of articles which have recently been printed on the subject of the average medical income, that statisticians are really entertaining serious thoughts in regard to a matter that presumably a false sense of pride has withheld altogether too long from a medical public that has known none too well the real facts in the case. But now that the smallness of the average medical income has been laid bare in the arena of our medical journals, the unwelcome truth can no longer be denied; and though in the future the average practitioner may hope to presume upon our credulity by assertions that glitter to the point of causing blindness, the weapons which we hold, thanks to the statisticians, will not fail to destroy his high-flown remarks about money flowing into his coffers. Thus we see that the enlightenment, which has been granted us through the labors of those who seek the truth, is such that it cannot but be a great help in bringing to book all those practitioners, who have been in the habit of flaunting their success before our envious eyes without the slightest demur on our part.

When the statisticians fixed on the sum of one thousand dollars as the average medical income, were they really good accountants, or merely croakers who saw that the medical times were out of joint? Though not in a position to answer either question satisfactorily, we yet feel that their main object was to quash all false ideas, which somehow grow too luxuriantly in the minds of recent graduates in medicine as to the ease with which the medical Eldorado may be captured. Thus, if it cannot be controverted that one thousand is the average income, the pioneer work, which these statisticians have done in ridding our budding physicians of all illusions, must rank with the best humanitarian undertakings of the age, for can it be denied that when one is fully prepared for the worst, strength of character is not protected? And surely a more than usual amount of will-power is necessary, if smiles are to take the place of sighs, when after years of patient waiting the average medical income remains the same with a persistence that is maddening, to say the least. To soothe the life of another fellow-man in the ranks of medicine is indeed a noble act, and until now thought an exceedingly difficult one; but armed as we are with statistics, how easy the task will be to convince him that as an average man he cannot possibly hope for more than an average income, though the price of the necessities of life is continually soaring skywards.

OPINION AND CRITICISM.

X-RAY NOMENCLATURE.

It would seem that the universal use of a physical agent for fifteen years would have provided a nomenclature, established by usage, warranted by euphony and exercised by general consent.

To William Conrad Roentgen all honor is due for a correlation of physical elements and a fortuitous foresight into unknown phenomena. There is good reason that his name should be indelibly impressed upon the subsequent history of his experiments. But there are also the claims of others to be considered and the necessity of striking a compromise as to a nomenclature of universal availability.

At the present time, the word "roentgen" is synonymous, in Germany and Austria, with the term "*x*-ray," "roentgenstrahlen," "roentgen laboratorium," and "roentgenization." In England, the term "*x*-ray" is more generally in use. In America, we indifferently apply the term and the word. That the German should promote the use of a name of international fame is characteristic of Germany and none the less commendable. That England should promote the use of the name "*x*-ray" is also worthy of attention. It was only by the use of the Crookes tube that the development of Roentgen's experiments proved valuable. The humble name *x*-ray, as used first by Roentgen himself, provides a characteristic appellation which, on account of its brevity and the ease with which it is written, should suffice for all nations.

We find that the coil of Ruhmkorff, the tube of Crookes and the mind-process of Roentgen have combined to place an invaluable agent at the service of mankind. The very nature of the gift to the world precludes the selfish use of a proper name to indicate the agent. As well use the proper names Bell or Morse to point out other beneficent inventions.

Some years ago, the American Roentgen Ray Society decided to promote the nomenclature as expounded by the Deutsche Roentgen Gesellschaft. This was no doubt fostered by the knowledge of the deep debt that the world owes to the experimental *x*-ray research of the German laboratories. But this would load our language with polysyllables which are more or less ridiculous in the English language.

It would therefore appear that the short, crisp name, *x*-ray, as used by Roentgen himself, would afford the happiest compromise irrespective of the nationality of the writer.

LITERARY NOTES.

No doubt by this time, every physician, who follows current matters with some degree of interest, has read about the epoch-making exhibits in New York and Chicago illustrative of the needs of the modern child. The Child Welfare Exhibit must bring home to all members of the medical profession the thought that hitherto, on account of our rather hysterical pursuit of diseases, we have really overlooked the fact that the child is father of the man, and that if we continue to withhold from it those things which make for its health and comfort we are not working at all in the interests of the community. We are not in a position to posit that Ellen Key, whose recently published book "Love and Marriage" has come to our desk, was the instigator of this movement, but what we can assert in all reason is that no one living to-day has taken a greater interest in the welfare of the child. Whether we read her "Century of the Child" or the book which has just been mentioned, the thought we gather is that here is a student of child-life whose every utterance carries weight. Ellen Key is no physician; hence, it would be futile to consult her about those phases of a child's life which most interest members of the medical profession, but within her limitations she evidences a psychology that shows the thinker who is not content to wander along the beaten paths. And it is well at all times to have among us both men and women who can think in their own individualistic way, even though out of this may arise several jolts to our supineness, which are far from being enjoyable. This Swedish woman is not afraid to write the truth as she sees it, in large fat letters, so that even the myopic cannot have the excuse that her messages cannot be read; and, though her attitude is to-day considered unconventional to the degree of daring, we feel that when a greater knowledge of the needs of the child is understood a more kindly criticism will be meted out to her.

In connection with the centenary of the King of Rome, M. Welschinger has recently published in the *Journal des Débats* some interesting anecdotes in regard to the accouchement of Marie Louise and the advice given by Corvisart, who was in attendance at that time. After the confinement which, by the way, caused considerable excitement not only on the part of Corvisart, but also on the part of Napoleon, by reason of its tediousness, Corvisart took Napoleon aside and told him that another crisis such as this in Marie Louise's life would surely end in death. Of course, words such as these coming from so eminent a medical man as was Corvisart could not but make an indelible impression on Napoleon; and though he might have forgotten the sinister words of warning had

Marie Louise's social status been that of Josephine, who was neither a king's nor an emperor's daughter, as regards Marie Louise it was an altogether different matter, for was she not the daughter of Emperor Francis I. of Austria, and was he not a mere bourgeois who was even then, despite his title, called by all royal families of Europe a vulgar upstart? And thus Napoleon did not forget the weighty words of Corvisart. But, as a prognosticator, Corvisart was even a greater failure than as an accoucheur of sound judgment and steady nerves, for when Marie Louise "married" Count Neipperg she bore him three children, and no Austrian accoucheur became panic-stricken lest the life of so valued a member of royalty should be eclipsed in childbirth.

Those physicians among us, who like Silas Wegg have a weakness for "dropping into poetry" in their leisure moments, should not fail to read Professor Ronald Ross's book of poems entitled "Philosophies," of which John Murray of London is the publisher. For by making an intelligent study of it, they must soon realize that the gift of poetry is not at all germane to science, even though the mental attainments, as in the case of Professor Ross, be far above the ordinary. Now, if our medical poetasters will but remember this, much will be gained, and no longer will a long-enduring and long-suffering public be called upon repeatedly to subject, with a good grace, its patience to the perusal of puerile poetical attempts which should have remained unborn. Professor Ross naively states in his preface that "friends who have read that part of them which is called "In Exile" complained that they could not easily follow the movement of it," and we may add that if "friends" were so completely in the dark, there is surely justification for our mental obscurity. It is said that after reading Browning's "Sordello," Mrs. Carlyle wished to know whether Sordello was a man, or a city, or a book; and the same thought occurs to us upon perusing with considerable patience line after line in this book. In exile in India is not a lot to be envied, as Kipling has so well told us in his unforgettable poem, "Christmas in India"; but though the plight of the banished one is bad enough, it is as nothing compared with our own when duty compels us to read the poems of those physicians and scientists who cannot withstand the lure of "dropping into poetry."

Among the books of travel, which have recently been published, none to our mind is more interesting than the collection of letters which appeared in the *Boston Medical and Surgical Journal* over the name of

"*Medicus Peregrinus*," and are now issued in book form as "*Litora Aliena*" by W. M. Leonard of Boston. These letters breathe a freshness and originality which must commend them to all readers who are somewhat jaded by the repetitious performances so often put forth in print as new interpretations of travel. Whether "*Medicus Peregrinus*" takes us to Lichfield and discourses about Dr. Johnson, or to London and walks us through the hospitals, the interest is the same, since his mind is ever on the alert for what will interest the reader of wide latitude. And there is just enough of medicine in the book not to frighten the general reader, or to weary the medical one as by a twice-told tale. In fact, what appeals to us most is the author's literary and historical enthusiasms and the cleverness of his many observations. Added to these the buoyancy of his style is never a negligible quality; and this surely is an asset when reading about places which otherwise might not interest the reader for long.

ORIGINAL ARTICLES.

RECENT STUDIES UPON THE ELECTROCARDIOGRAM AND UPON THE CHANGES IN THE VOLUME OF THE HEART.

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PART I.

THE ORIGIN AND COURSE OF THE CARDIAC IMPULSE AS REVEALED BY PHYSIOLOGICAL AND CLINICAL STUDIES, ESPECIALLY THOSE WITH THE ELECTROCARDIOGRAM.

New methods lead to the discovery of new facts, new facts to new doctrines, new doctrines to new lines of treatment.

The more recent conceptions, regarding the origin and course of the normal and pathological impulse in the heart, have been the direct result of the introduction of two new methods for studying them in man; namely, the venous pulse and the electrocardiogram.

The study of the curve obtained by recording the wave of pulsation over the jugular vein had been in vogue since the studies of Friedreich and Marey in the middle of the last century, but did not attain practical importance until James Mackenzie in 1893 began to record the curves over the jugular vein and that over the carotid artery, simultaneously. The first wave in the jugular pulse revealed the contraction of the auricle; the carotid wave revealed the contraction of the ventricle, and a comparison of the sequence of the two enabled Mackenzie to interpret the sequence of the cardiac chambers in the normal and the irregular hearts of his patients. The use of this method enabled Mackenzie¹ to study the arrhythmias of his patients' hearts in the light of Engelmann's studies upon experimental irregularities in the frogs' hearts, and the use of the same method enabled W. His, Jr., in 1899, to demonstrate the dissociation between contractions of the auricles and ventricles in a patient suffering from Adams-Stokes disease, and to interpret it in the light of Gaskell's studies upon the frog's heart. These studies with their experimental confirmations by Hering, Erlanger and a host of others, formed the basis of the modern conceptions of cardiac pathology.

However, it soon became apparent that great as were the advances due to the phlebogram, the method had its limitations, for it was im-

possible to determine in which auricle or in which ventricle a disturbance of rhythm arose, and in order to obtain new light upon these points another method had to be devised.

The method which promises most from this standpoint is the study of the electrical variations accompanying the cardiac contraction, or the electrocardiogram.

The study of the electrocardiogram in man was not new to physiologists, since it was made with the capillary electrometer by Ludwig and his pupil, Waller² in 1887, and revived by Einthoven³ of Leyden in 1895; but the electrical variations which are from 1/10,000 to 1/3,000 of a volt were too slight to be indicated by this means. However, in 1906 Ein-

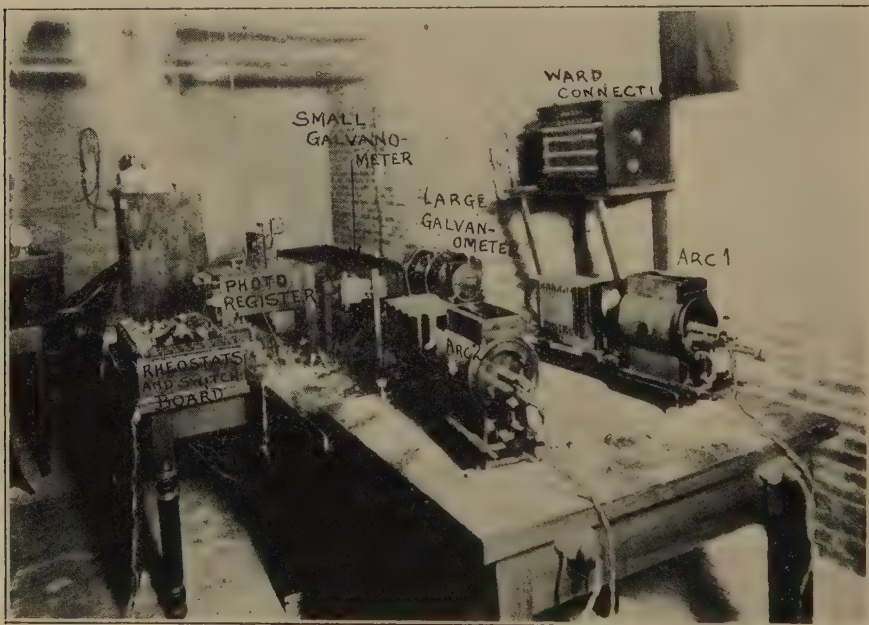


Fig. 1.—Photograph of the electrocardiograph installed at the Johns Hopkins Hospital.

thoven invented a new type of galvanometer, now known as the string galvanometer or thread galvanometer, whose delicacy was sufficient for the purpose (Fig. 1). This galvanometer depends upon the well-known fact that a current generates a magnetic field acting at right angles to its course, which varies with the strength of the current, and which may thus exert a varying attraction or repulsion upon a second magnetic field in its vicinity.

The current from the body, which is thus varying in intensity, is carried upon a quartz or platinum filament about $3\ \mu$ (.003 mm.) thick, which is so light that its weight is negligible, for it cannot be weighed with

the most delicate balances. It is suspended between the poles of a very powerful electro-magnet with large cast-iron armatures. The movements of the thread are recorded by projecting its shadow under the magnification of a high-power microscope upon the slit of a specially devised camera, about six feet away. The film of this camera moves rapidly past the slit, and the oscillations of the thread are recorded as a curve. The time is indicated by the shadow of a time marker placed in front of the slit.

The current is led off from the body from German silver electrodes which are padded with felt soaked in physiological salt solution (Fig. 2 +, -). The current thus obtained represents the difference of potential between the skin under two electrodes, and is generated by two

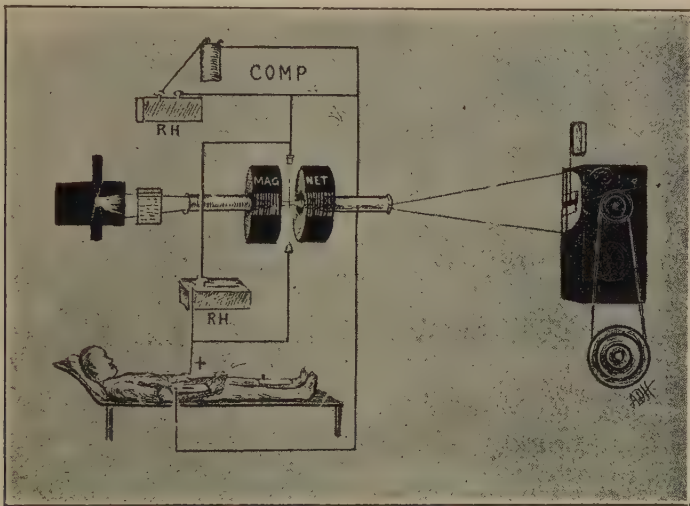


Fig. 2.—Diagram showing the simplest arrangement of the connections for the electrocardiograph. RH, Rheostat; COMP, compensating current.

elements: 1. The permanent difference of potential between these two different parts of the body, which is dependent upon local conditions of the skin and tissues and is quite independent of the cardiac cycle. This is known as the current of rest. 2. The oscillations due to the action current of the heart itself, the electrocardiogram proper. Since we are interested only in the latter, the *current of rest* is neutralized by passing through the galvanometer a battery current exactly equal to it, but opposite in direction. After which compensation the only current acting upon the galvanometer is that which accompanies the contraction of muscles. When the patient is quiet, the tonic contractions of the skeletal muscles play but a little rôle, and the action-current that is observed is seen to accompany cardiac contractions (Fig. 3). Contraction of the hand or foot muscles exerts a definite effect, which is much slower

than the cardiac impulse; and the same is true of the wave accompanying deep inspiration.

It has become conventional to obtain tracings in man with the electrodes in three sites:—

- 1st. Lead or Derivation (D 1).....Right hand and left hand;
- 2nd. Lead or Derivation (D 2).....Right hand and left foot;
- 3rd. Lead or Derivation (D 3).....Left hand and left foot;

but for special purposes Kraus and Nicolai use the right hand to right foot, left hand to right foot, right foot to left foot. Thomas Lewis has found that he could study the contractions of the auricles more closely by using the electrodes over the precordium and back.

A curve representing the electrical variations due to the heart-beat is

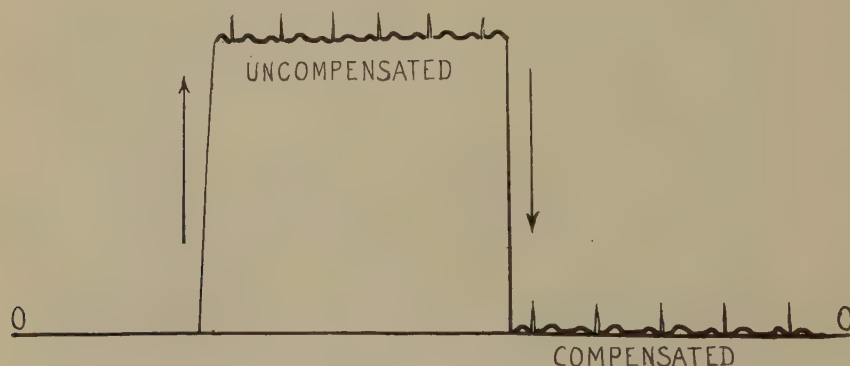
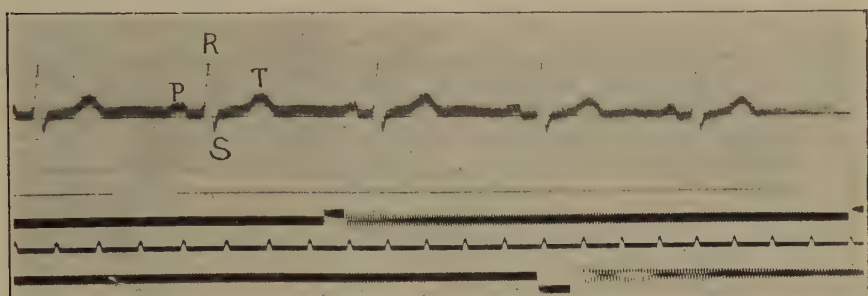


Fig. 3.—Diagram showing the body current and the heart currents, and the effect of the compensating current.

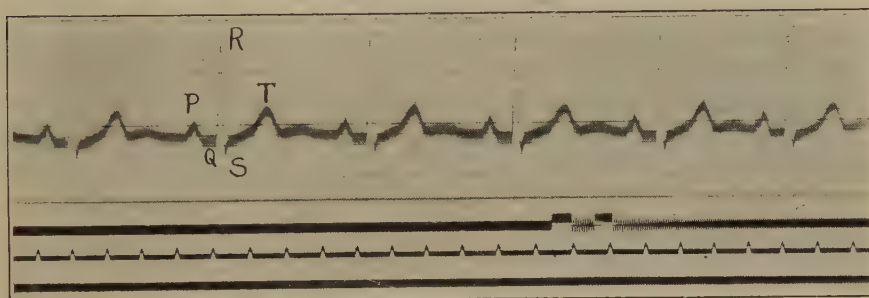
known as an electrocardiogram and that of a normal heart-beat is shown in Fig. 4.* The first part of the curve is represented by a small wave which Einthoven designates by P (presystolic wave) equivalent to a variation of $\frac{2.4}{10,000}$ volt, coincident with the onset of auricular systole. This is followed by a small depression, Q, below the base-line just before the electrical wave of the ventricle. The ventricular wave (R) is the largest wave of the curve and represents about $\frac{3.4}{1,000}$ volts. It sets in and subsides within .02 second, and then falls below the base-line to form a depression, S, just before the mechanical contraction of the left ventricle sets in. This is followed by an instant during which the curve remains near the base-line, and then it gradually ascends to form a wave, T, lasting about .1 second in midsystole. There are no waves at the end of systole or in the diastolic period until the beginning of auricular contraction.

*The electrocardiograms presented in this paper were kindly made for me by Dr. G. S. Bond, Assistant in Medicine, Johns Hopkins Medical School, whom I take pleasure in thanking for his hearty co-operation.

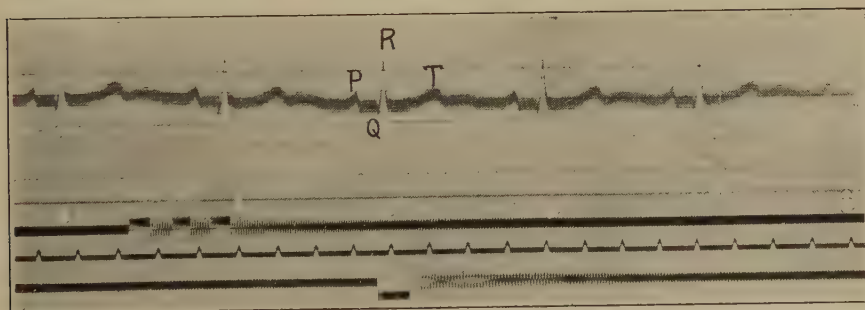
In the perfectly normal curve the tracings taken in the different leads are quite similar (Fig. 4) except that the R wave is largest in the second derivation (D 2). As will be seen, it is not a simple curve, nor



A.



B.



C.

Fig. 4.—Electrocardiograms from a normal man.

A. Tracing taken with the electrodes upon the right arm and left arm (D1).

B. Tracing taken with the electrodes upon the right arm and left leg (D2).

C. Tracing taken with the electrodes upon the left arm and left leg (D3).

The lowest line and the third line from the bottom represent signals, the second line from the bottom represents time in $\frac{1}{5}$ seconds.

does each wave correspond to the contraction of a single chamber, but it is more or less of a composite, the resultant of several different factors. Nicolai has shown that if the heart is upon the right side, dextrocardia, the electrocardiogram is of normal form, but entirely inverted.

It must be remembered, as Gotch and Florence Buchanan have pointed out, that these waves represent the difference of potential between the skin under the two electrodes. If both electrodes remain entirely free from charge, the curve remains at the base-line. But if both electrodes receive an electric charge of the same intensity (say, four millivolts), the difference of potential between them remains zero, and the curve remains at the base-line. It is a matter of empirical fact shown by Kraus and Nicolai that the contraction originating at the base of the right ventricle causes a wave exactly opposite in sign to that accompanying a contraction originating at the left apex; and it has been assumed by these writers that the ventricular part of the normal electrocardiogram represents the algebraic sum of two such almost equal and opposite currents, but that the R S wave, which occurs before the onset of the mechanical contraction, is caused by the impulse passing down the cells of the atrioventricular conduction system. In conformity with this hypothesis, Nicolai⁴ found all the waves inverted in a patient with dextrocardia; but on the other hand Gotch⁵, Buchanan, Straub, and Samojloff found electrocardiograms similar to those of mammals in frogs, snakes and tortoises, in spite of the fact that these animals possess but one ventricle.

Florence Buchanan suggests that it may not be the separate ventricles, but the separate layers of muscle fibres which arise in each papillary muscle. She suggests, moreover, that the R wave is produced by a slight asynchronism between the two ventricles, so that one ventricle only is acting during the instant in which the R wave occurs. This view is shared by Rothberger and Winterberg.⁶ Such an asynchronism has indeed been shown by Knoll,⁷ Frédéricq,⁸ Stassen,⁹ Barker and Hirschfelder¹⁰ during vagus stimulation, and it is possible that even under normal conditions it may exist for a period long enough to just give rise to the deflection of the R wave. It must be admitted that neither of these theories has been proved and both await the confirmation of further experiment.

Whatever may be the factors which give rise to the curve, experiments based upon variations in its form tend to throw some light upon other questions of physiological importance. One of these questions pertains to the site at which the cardiac impulse arises. By homology with the amphibians and reptiles it has always been assumed that the cardiac impulse arises in the region corresponding to the sinus venosus. In the mammalian embryo the sinus venosus or sinus reuniens exists as a separate chamber bounded by the mouths of the venæ cavæ, the interauricular septum and the Eustachian valve, which at this stage of development is relatively large and almost completely partitions it from the cavity of the auricle. As the heart grows, however, the region about the Eustachian valves grows very little, and the sinus reuniens becomes incorporated within the right auricle, so that in the adult it is repre-

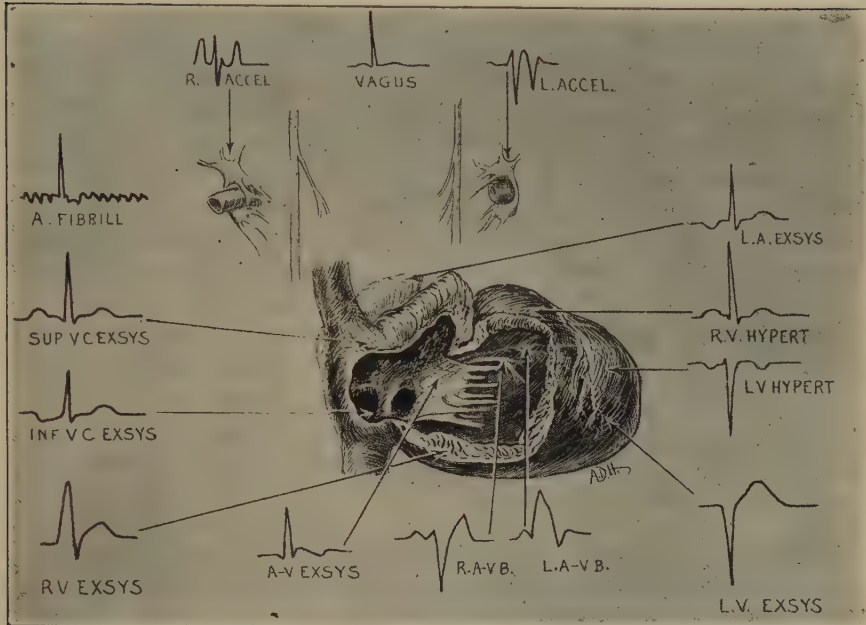


Fig. 5.—Diagram showing abnormal electrocardiograms and the structures in which they arise.

R.ACCEL, electrocardiogram resulting from stimulation of the right accelerator nerve; P, S, T waves increased, R wave diminished.

L.ACCEL, effect of stimulating the left accelerator; P and R waves diminished, S wave increased, T wave inverted.

A. FIBRILL, auricular fibrillation, P wave absent, replaced by numerous small undulations.

SUP V.C.EXSYS, right auricular extrasystole arising in the vicinity of the lower end of the superior vena cava (especially in the vicinity of the Keith-Flack node); all the waves normal.

INF V.C.EXSYS, right auricular extrasystole arising in the vicinity of the inferior vena cava; P wave inverted.

L.A.EXSYS, extrasystole arising in the left auricle; P wave inverted.

R.V.HYPERT, hypertrophy of the right ventricle, all the waves normal, but R wave increased.

L. V. HYPERT, all waves, but especially the R wave inverted; or S wave increased.

RV EXSYS, extrasystole arising in the right ventricle, showing an absence of the P wave, and an abnormal ventricular wave, consisting of a large initial wave followed by a depression and a second smaller wave.

LV EXSYS, extrasystole arising in the left ventricle, showing a large initial depression followed by a large slow wave.

A-V EXSYS, extrasystole arising in the node of Tawara or the His auriculo-ventricular bundle, accompanied by synchronous contraction of auricles and ventricles, showing absence of the P wave and slightly abnormal ventricular waves.

R A-V B, electrocardiogram due to a myocardial lesion affecting the right branch of the auriculoventricular bundle; P wave normal, other waves resembling those due to a left ventricular extrasystole.

L A-V B, electrocardiogram due to a myocardial lesion affecting the left branch of the auriculoventricular bundle.

sented by only a few bundles of smooth muscle fibres lying indefinitely between the venæ cavæ and the auricle proper (Fig. 5). In 1906 Wenckebach described one of these bands which crossed the veno-auricular junction from the superior vena cava to the upper surface of the right auricle and penetrated downward toward the coronary sinus. This was soon confirmed by Keith and Flack,¹² who showed that there was connective tissue all around this bundle or node, although they showed that there were other muscular connections with both superior and inferior venæ cavæ. Their anatomical observations have been confirmed by Schœnberg,¹³ W. Koch,¹⁴ Lewis and Oppenheimer¹⁵ and a host of others.

MacWilliam¹⁶ and later Adam¹⁷ had shown that the intervenous region is the only one at which the application of heat or cold changes the pulse rate.

Frédéricq, Langendorff and Lehmann,¹⁸ and Erlanger and Blackman¹⁹ brought a good deal of evidence to show that the contraction begins in the right auricle and is dependent upon the region around

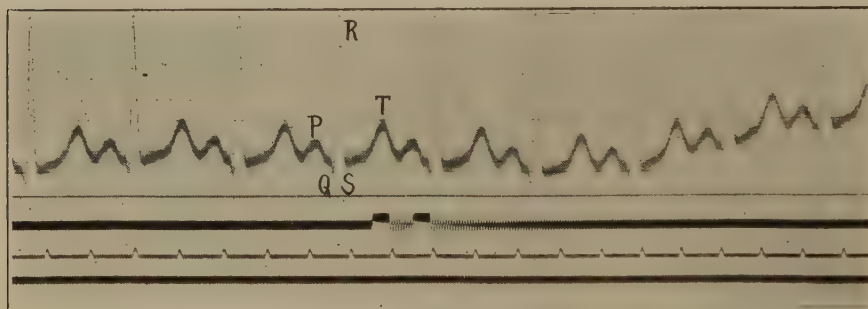


Fig. 6.—Tracing taken in D2 showing hypertrophy of the right ventricle.

the great veins. Quite recently, however, Wybauw has shown by means of the electrocardiogram that the region of Keith and Flack's node becomes negative before any other part of the auricle, and Lewis and Wybauw²⁰ have shown that when artificial stimuli (induction shocks) are applied to any other part of the heart the resultant electrocardiogram is atypical, and that an electrocardiogram of normal form is obtained only as the result of stimuli arising at the Keith-Flack node. Cohn and Kessel²¹ have found that excision of this region was followed in most of their perfused hearts by great slowing of the heart. Flack and also Jæger,²² however, have destroyed it without producing any marked disturbance of rhythm, so that in spite of the predominance of evidence in favor of the Keith-Flack node as the normal pace-maker of the heart, some contradictory evidence still remains to be explained.

In the frog it can be seen that the contraction which originates in the sinus passes on to the right auricle. Bond²³ has demonstrated that just after the contraction of the auricle, the muscle fibres about the auri-

culoventricular ring may be seen to contract, and this is followed by contraction of the ventricle. In the mammalian heart it is probable that the same sequence takes place. From the right auricle it passes to the ventricles over the His bundle and its ramifications, the so-called conduction system. As His,²⁴ Keith,²⁵ and Tawara²⁶ have shown, this system of fibres is distributed in the form of the Greek letter λ . The upper end is composed of a dense plexus of peculiar muscle fibres, the so-called Purkinje fibres, mononuclear striated muscle cells smaller than the ordinary heart-muscle cells and very rich in perinuclear granules. The shaft of the λ forms the bundle first described by His which runs in the membranous septum only to bifurcate into two limbs which straddle the muscular septum, split up into subendocardial and intramuscular fibres and distribute themselves to the wall and papillary muscles of the corresponding ventricles. The bundle is quite rich in non-medullated nerve fibres and as Wilson²⁷ has shown, contains a number of ganglion cells.

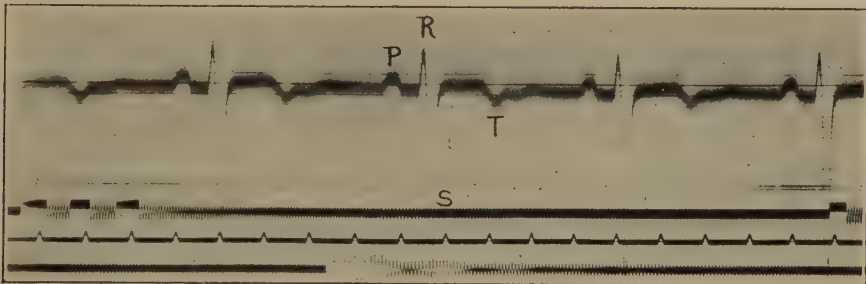


Fig. 7.—Tracing taken in D3 showing hypertrophy of the left ventricle.

As regards the action of the cardiac nerves, Rothberger and Winterberg have found recently that stimulation of the left accelerator gives a curve typical of overaction of the left ventricle, with inverted R and T waves, while stimulation of the right, besides acceleration, gives a curve resembling that of overaction of the right ventricle, *i. e.*, very large P, R, and T waves (Figs. 6 and 7). These curves are exactly similar to the curves, which, when obtained permanently, correspond to hypertrophy of the corresponding ventricle, as Einthoven has shown. They furnish also experimental confirmation for the anatomical findings of Lim Boom Keng²⁸ and v. Schuhmacher,²⁹ that the right and left cardiac supply the corresponding halves of the heart and spread but little to the opposite side.

Rothberger and Winterberg found further that stimulation of the left stellate ganglion, at a period when the action of the sinus region was depressed by cooling with ethyl chloride, gave rise to synchronous contractions of auricle and ventricle, which could result only from stim-

uli arising in the bundle of His (Mackenzie's nodal rhythm). In these cases the electrocardiogram shows no P wave whatever, because the P falls in the time of the R wave. The pulse rate in such cases is not extremely fast nor nearly as high as that in paroxysmal tachycardia.

By means of the electrocardiogram, as well as the phlebogram, it is possible to divide the arrhythmias into several distinct groups:—

I. Irregularity of extracardiac origin, simple changes of rate or instability of rhythm due to periodic stimuli arising in the extracardiac nerves, the vagi or the accelerators. These nerves are normally in constant tonic activity, and the resultant of their tonic activity determines the heart rate. We know, of course, that stimulation from the cerebral cortex inhibits the vagi and stimulates the accelerators, and thus causes a quickening of the heart rate. We know that increased intracranial pressure causes a stimulation of the vagi and a slow heart-rate. Other stimuli which act upon the vagus center in the medulla may cause such an inhibition or slowing of the pulse. The most common of these periodic

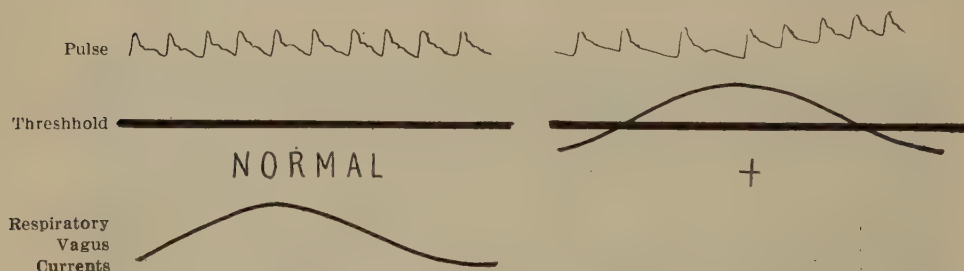


Fig. 8.—Diagram showing the relation of the afferent impulses in the vagus to the threshold of irritability of the medulla. +, medullary irritability increased. The tracing shows the respiratory arrhythmia.

stimuli comes up from the diaphragm at each inspiration. Einthoven, Flohil and Battærd³⁰ have recorded the electric changes in the vagus, and found that at each inspiration there is a wave of negativity (Fig. 8). Ordinarily this has no effect, because it is far below the threshold of stimulation to the medulla. But if any other stimulation is present and added to this, it may raise the reflex stimulation above the threshold and cause it to become an active stimulation, so that we may have a slowing (or sometimes quickening) at this point.

Reflex stimulation of this sort may reach the medulla:—

1. From cortical excitement (emotion or neurasthenia).
 2. From intracranial pressure (meningitis, brain tumor, etc.).
 3. Reflexes from nasal septum.
 4. Reflexes from abdominal organs (uterus, stomach, intestines, prostate, enteroptosis).
 5. Increased irritability from toxic agents (tobacco, tea, coffee).
- In all these cases the arrhythmia can be removed by a dose of atro-

pine, and in all, except the intracranial pressure group, the blood-pressure is usually low.

II. Tumors or adhesions along the course of the vagi or accelerator nerves, which may press or tug on these nerves during inspiration.

IRREGULARITY ARISING WITHIN THE HEART ITSELF TO ABNORMALITIES IN THE ORIGIN OR PROPAGATION OF THE IMPULSE.

All these forms may arise from the action of poisons upon the heart muscle. Most are to be found in the two classic papers of Cushny on digitalis and aconite. The diseased heart muscle acts in general like a poisoned heart muscle, and may indeed always be an example of a chronic

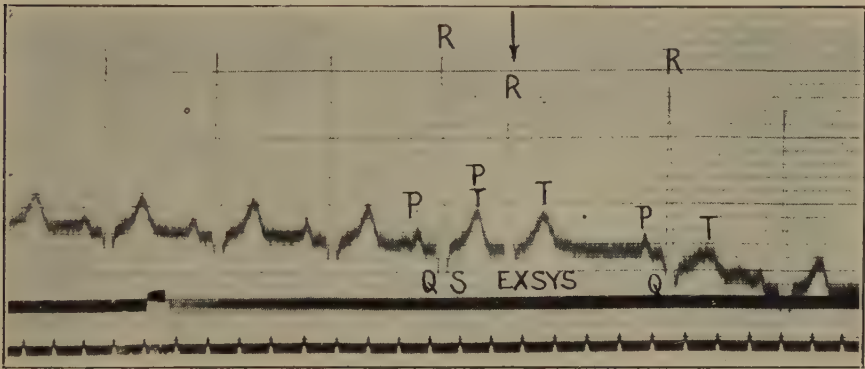


Fig. 9.—Tracing taken in D1 showing an auricular extrasystole arising near the superior vena cava. EXSYS, extrasystole.

poisoning. Most of the cardiac irregularities are brought about by the occurrence of abnormal beats, which in turn correspond to a heightened irritability of the walls of the chamber in which they arise. Abnormal contractions may be of three types—(Hirschfelder³¹):

1. Occasional premature beats (extrasystoles) followed by pauses, causing an irregular rhythm.
2. Approximate doubling of the previous rate setting in suddenly and subsiding suddenly.
3. Fibrillary contractions, rapid irregular contractions in which the fibers of the chamber wall no longer contract simultaneously, but contract one by one without co-ordination, causing an irregular wavy movement of the cardiac wall which expends energy, but does not pump the blood onward.

These three grades correspond to an ascending order of irritability: normal, $\longleftrightarrow$ extrasystoles, $\longleftrightarrow$ doubled rhythm, $\longleftrightarrow$ fibrillation, as can be shown by the following experiment: If we increase the irritability of

the wall by the mildest faradic stimulation, there is no appreciable effect on the pulse rate. If we increase the intensity of the stimulus a little more, the rhythm becomes irregular, by the occurrence of occasional premature beats (extrasystoles) which replace some of the regular beats and are followed by a pause, longer than the usual interval between the heart beats. The regular beat + premature beat (extrasystole) + pause are known as a "bigeminy." In clinical and pathological conditions such heightened irritability is usually the result of stasis and sudden dilatation of the chamber, from inability of the heart to empty itself, from stenosis of a coronary artery (Lewis),³² or from action of some poison upon the heart muscle. Extrasystoles may also occur perhaps reflexly in gastro-intestinal disturbances, especially gastro-intestinal distention.

Extrasystoles may arise in any part of the heart—in the sinus region, in other parts of the right auricle, in the left auricle, in the auriculoven-

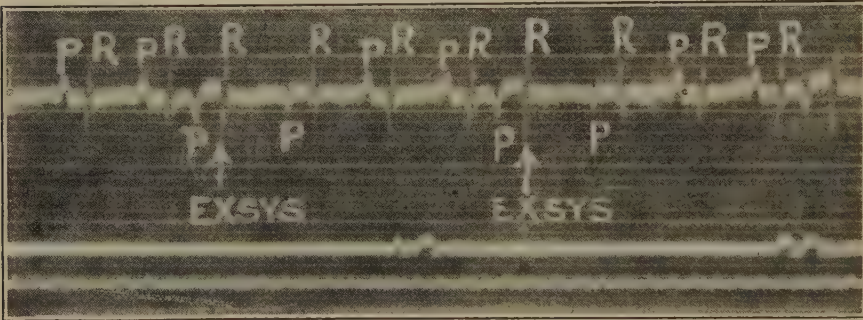


Fig. 10.—Tracing showing auricular extrasystoles arising from an abnormal site.

The P waves of the extrasystoles are inverted.

tricular bundle, in the right ventricle, or in the left. Each of these forms has certain distinctive characteristics by which it may be recognized clinically.

In all auricular extrasystoles, in contrast to ventricular extrasystoles, the form of the venous pulse wave is normal, though occurring prematurely, and the jugular pulsation presents nothing abnormal on inspection, except irregularity in rhythm. The pause following the extrasystole may be shortened (bigeminy less than the time of two regular pulse intervals.)

By the ordinary graphic methods, studies by Hirschfelder and Eyster³³ have failed to reveal any differences between extrasystoles produced experimentally in different parts of the auricles, but recently Lewis and Wybauw have shown that this may be done with the electrocardiograph. According to these observers, an extrasystole which arises from a stimulus near the superior cavo-auricular boundary has the normal form of electrocardiogram and differs from the normal only by having smaller R and T waves. The P wave is normal (Fig. 9). If the extrasystole

arises in the vicinity of the inferior vena cava, the P wave is inverted (Fig. 10); but as he and Rothberger and Winterberg have shown, this may also be true when it arises in the left auricle.

When the extrasystole arises in the cells of the auriculoventricular bundle, the impulse is conducted in both directions and the auricles and ventricles contract simultaneously. Bond has been able to watch this process in the frog, in which he could see the auriculoventricular muscle fibers contract first, and this was followed by the contractions of auricles and of the ventricle, which contracted at the same instant. In mammals it cannot be decided whether the fibres of the conduction system conduct or merely contract, but extrasystoles in which auricles and ventricles contract simultaneously (nodal extrasystoles) are occasionally met with. In

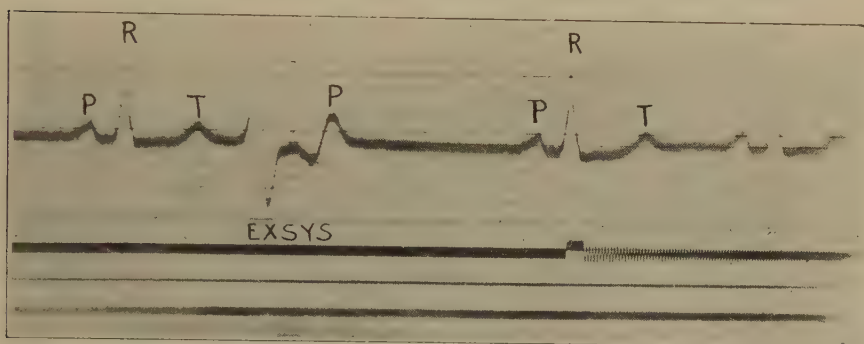


Fig. 11.—Tracing taken in D1, showing an extrasystole arising in the right ventricle.

The extrasystole is followed by a contraction of the auricles (P wave) occurring at the usual time.

the venous pulse these are indicated only by an absence of the auricular (a) wave and in the electrocardiogram by the entire absence of the P wave, while the normal R and T still persist. This form of electrocardiogram is pathognomonic.

Extrasystoles may also arise in either ventricle (Figs. 11 and 12), especially when there is a high blood-pressure and the chamber fails to empty itself. No matter where the extrasystole arises, the two ventricles contract almost synchronously, though the chambers in which the abnormal impulse arises may precede the other ventricle by about .02 second. Kraus and Nicolai have shown that the electrocardiograms of these extrasystoles are absolutely characteristic for each chamber. The venous pulse tracing, therefore, shows merely that a ventricular extrasystole has occurred, as indicated by the large wave during ventricular systole not preceded by an auricular (a) wave; but as Kraus and Nicolai have shown, the electrocardiogram gives tracings which are absolutely typical for right and left ventricle, and indeed are quite opposite in sign. Such

electrocardiograms have shown, in the same patient, extrasystoles sometimes in the right ventricle, sometimes in the left (Fig. 13).

Clinically, extrasystolic irregularities are very common, and the question naturally arises as to what pronostic significance we shall attach to them. Most observers, among them Mackenzie³⁴ and Mueller,³⁵ believe that the occurrence of extrasystoles always indicates the presence of a focus of myocarditis, and a more or less extensive lesion of the heart muscle, but this view is founded upon evidence that is by no means conclusive. Mackenzie, who has by far the most extended experience, states that he has had patients with occasional extrasystoles, who have been under observation for many years without appreciable change in their condition. It is quite frequent to meet with persons, otherwise apparently healthy, who are subject to extrasystoles during periods of

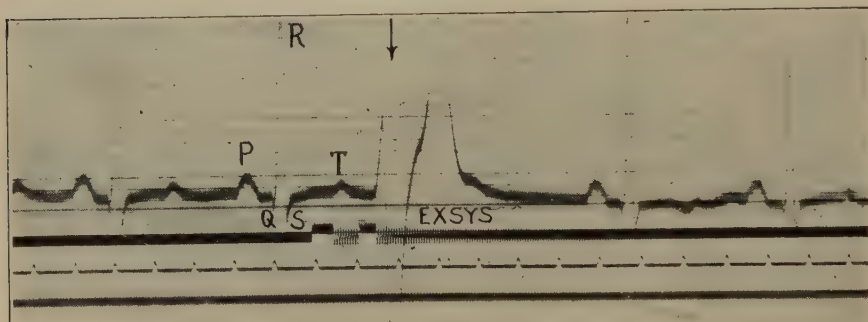


Fig. 12.—Tracing taken in D2, showing an extrasystole arising in the left ventricle.

gastro-intestinal disturbance, especially flatulence and tympanites. Each extrasystole may be accompanied by a distinct sensation of palpitation, and may be a source of great annoyance to the patient; and yet the latter is able to undergo muscular exertion without signs of cardiac weakness. In such persons, as Mackenzie states, the extrasystoles may be regarded as of no little or no prognostic significance, and the patient's general condition may be taken as the best index. There is another group of cases, however, whose heart rate is regular when at rest, but in whom extrasystoles set in as a result of exercise. In these persons the extrasystoles are to be regarded as an expression of a definite form of cardiac weakness, and they must then be taken into consideration like dyspnea, precordial pain, or any of the other danger signals of the circulation.

When the irritability of the heart is very much increased or there is persistent stasis in the auricles, the co-ordinate contractions of the latter may give way to fibrillary contractions. Hirschfelder and Eyster have found with the capillary electrometer, and Rothberger and Winterberg³⁶ and Lewis³⁷ with the Einthoven galvanometer, that the electrical varia-

tion accompanying each fibrillation is about as great as that accompanying each regular auricular contraction; and so one may suppose that the cardiac stimulus is about as great. Hirschfelder³⁸ has found that when a heart is stimulated by induction shocks too fast for it to follow, it responds more or less irregularly, at first by the omission of a few beats and an occasional beat, and in other cases by responding to only half or one-quarter of the original number of stimuli. It seems probable, therefore, that the fibrillating auricle with its 400 to 600 impulses per minute gives birth to such stimuli—impulses which are too fast for the ventricles to follow completely. Accordingly, the ventricles respond irregularly, sometimes to one impulse, sometimes to another, and a permanent irregularity in which, as the electrocardiogram shows (Fig. 14), the ventricular impulses follow the normal course along the auriculoventricular bundle.

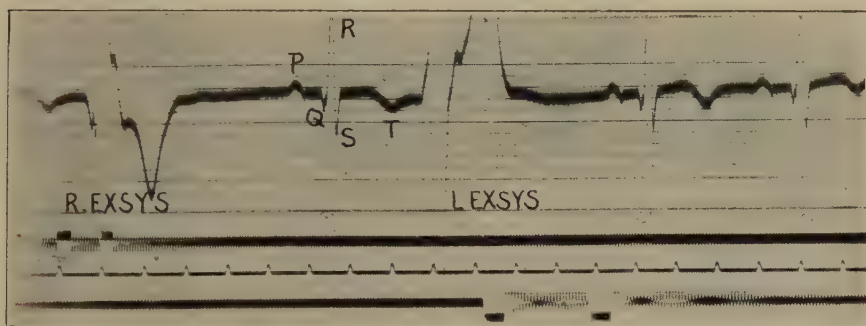


Fig. 13.—Tracing taken in D2, showing one extrasystole arising in the right ventricle and one arising in the left ventricle.

It is this form of arrhythmia which constitutes a large proportion of the absolute arrhythmias that are common in cases of old mitral disease and old myocarditis, and which Mackenzie formerly supposed to be due to a "Nodal Rhythm." The veins in these cases are usually full, and since the auricles no longer contract forcibly, the auricular (a) wave is absent from the venous pulse and the P wave from the electrocardiogram. The venous pulsation is either entirely absent or is represented by a single wave with a plateau or M-shaped crest coincident with ventricular systole. The electrocardiogram shows a normal R wave or an inverted with T usually diminished or absent; but the characteristic feature lies in the fact that the P wave is absent and the fibrillary contractions of the auricles are represented by irregular undulations occurring during both the systolic and the diastolic periods.

Clinically, it is usually, though by no means always, possible to diagnose this form of arrhythmia by simple inspection of the jugular pulsation. In these cases the jugular pulse is "single" (*i. e.*, one pulsation accom-

panying each beat of the heart or each carotid pulsation) in contrast to the normal venal pulse which is "double" (two pulsations accompanying each heart-beat). The pulsations are almost always very small and the veins stand out full and prominent. Ventricular extrasystoles, which are occasionally present, can be distinguished as large waves which shoot up along the external jugular even as far as the upper border of the sternocleidomastoid, furnishing a striking contrast to the small pulsations from the auricular fibrillation.

Irregularities of this form often persist for years, and usually are accompanied by a condition of cardiac dilatation and weakness (Fig. 22). They may be present in mitral disease during the transition periods of heart failure, with the subsidence of which the rhythm returns to normal. Occasionally persistent fibrillation of the auricle and permanent irregularity may persist in an individual who is not suffering from symptoms of cardiac weakness, and as such it may not greatly affect the duration

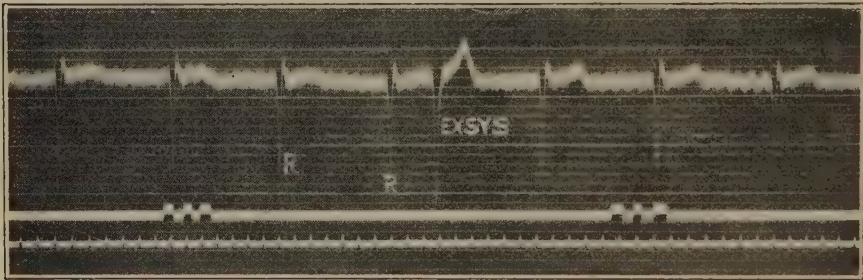


Fig. 14.—Tracing taken in D3, showing auricular fibrillation, absolute arrhythmia, and hypertrophy of the left ventricle; also one extrasystole arising in the left ventricle.

of life. It is this form, as Cushny³⁹ and Windle⁴⁰ have shown, which shows the greatest improvement under digitalis, probably because the latter stimulates the vagus, and, by blocking many of the irregular impulses from reaching the ventricle, allows the latter to attain a slower rate and thus to recover. The prognosis in most cases of auricular fibrillation is therefore not a good one, though the condition itself does not spell impending death.

The ventricles, which are the motive power of the circulatory pump, pump strongly though not regularly, and continue to pump at a rate which maintains the velocity of the blood stream and responds to its altered needs. More commonly, however, when the auricle fibrillates, the ventricle is already following at its fastest pace and cannot increase its rate to meet increased demands upon it during exertion. It is measured entirely by the ability of each heart to respond to the increased demands upon it; by the symptoms of the patient rather than by the nature of the arrhythmia.

Another very closely allied form of disturbed rhythm with increased irritability is the condition known since Bouveret⁴¹ as idiopathic paroxysmal tachycardia. In this condition, as in the experiments already quoted, the heart rate suddenly, within a single cardiac cycle, rises to about double the original rate, and persists at this rate for a time varying from a few seconds to weeks or even months, subsiding equally suddenly to the original rate.

Such paroxysms cannot be produced by either paralysis of the vagi or stimulation of the accelerators in man or animals (Gerhardt,⁴² Hirschfelder). They can, however, be reproduced in dogs by faradizing the auricles (Hirschfelder) or by ligating the right coronary artery (Lewis).

By the former method four types may be obtained:—

1. Approximate doubling of the auricular rate, with lengthened or with shortened conduction time.*
2. "Doubled" rate, with synchronous contractions of auricle and ventricle (nodal tachycardia).
3. "Doubling" of the rate in the ventricle, which may precede the auricle and become the pace-maker of the heart.
4. Fibrillation of the auricle, which the ventricle follows at a regular rate instead of at the irregular rate characteristic of the absolute arrhythmia.

In man, two types of paroxysmal tachycardia have been observed, some with a persistent (a) wave upon the venous pulse and some with a venous pulse of the ventricular type. The former is more common in cases with short paroxysms. Lewis⁴³ and Marris⁴⁴ have thus far described paroxysms of the auricular and the nodal type in man, and cases seen at the Johns Hopkins Hospital have all shown normal or inverted P waves, so that the causation of such paroxysms from ectopic auricular impulses in man is certain. Up to the present, no definite examples of auricular fibrillation in human paroxysmal tachycardia have been revealed by the electrocardiograph, so that it is evident that the response of the human heart and that of the dog's heart to auricular fibrillation are different. While the dog's heart, which is capable of a more rapid rhythm, may respond to the fibrillation with a perfectly regularly beating ventricle, at the accelerated rate this pace becomes too fast for the human ventricles to follow, and the rhythm becomes irregular. Whether paroxysms of tachycardia without irregularity ever results in man from auricular fibrillation can be decided only after a sufficient number of cases have been observed with the electrocardiograph.

The tendency to paroxysmal tachycardia seems to indicate a physiological state of the heart muscle, rather than an anatomical lesion, for in some cases it may be present for thirty or fifty years without any accompanying heart failure or indeed any lesion in the heart at autopsy. In

*The change of rate consists in an absolutely abrupt increase to from 1.6 to 2.1 times the previous heart rate, setting within less than the period of two cardiac cycles and subsiding with the same suddenness.

others, however, especially where there is some complicating disease, it accompanies disease of the coronary arteries (Romberg⁴⁵), and then, of course, it is of grave significance. Occasionally the paroxysms are brought on whenever the patient sits up in bed (orthostatic type), Hewlett,⁴⁶ but they are usually quite independent of posture and muscular exertion.

Disturbances in conductivity and contractility and diminution of irritability may also lead to disturbances of rhythm, notably to heart-block.

If the auriculoventricular bundle is injured either by an organic lesion, by asphyxia, or by a poison such as digitalis or aconite, the cardiac impulse no longer reaches the ventricle, or reaches it only occasionally. Gaskell⁴⁶ has shown in frogs and turtles, and Erlanger⁴⁷ in mammals, that if the auriculoventricular bundle is slowly clamped, the conduction

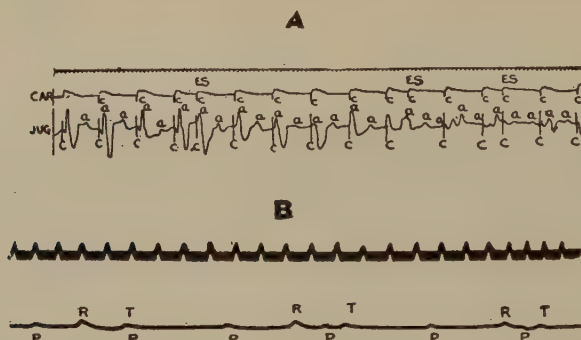


Fig.15.—A, venous and carotid arterial pulse from a patient with complete heart-block and pulse-rate of 33 per minute. B, electrocardiogram from the same patient. Upper line, timer in fifths of seconds, lower line, electrocardiogram. The rate of the atria is about twice that of the ventricles but the complete dissociation between the two is more readily discernible in the electrocardiogram than in the venous tracing.

(After Barker, Hirschfelder and Bond, *Jour. Amer. Med. Assoc.*, 1910, lv., 1350).

Tracing taken with the small Edelmann galvanometer.

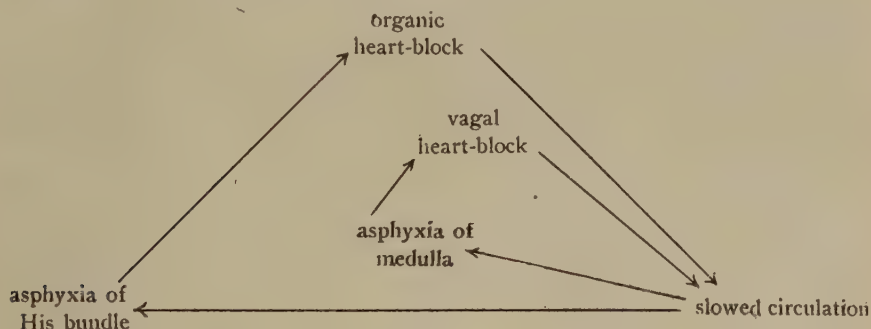
time is at first gradually lengthened, then alternate beats of the ventricle drop out (partial heart-block, 2:1 rhythm), then the block becomes still more intense and a 3:1 or 4:1 rhythm results. If the clamp is now still further tightened, or if from the first it was tightened suddenly, all impulses are cut off from the ventricles and the latter cease to contract for a considerable period (several seconds to half a minute) until they develop a rhythm of their own, which is slower than the rate of the auricles, but bears no relation to them. This pause and subsequent development of the rhythm, as shown by His and Erlanger, represents the cessation of the pulse, the period of syncope, and the onset of bradycardia in the Adams-Stokes syndrome.

Heart-block can in most cases be diagnosed clinically by inspection of the venous pulse, when in a case of bradycardia three or more wavelets can be discerned over the jugular vein for each pulse wave in the carotid,

especially if synchronously with these wavelets the faint ticking sounds of auricular contractions can be made out over the heart. Care must be taken, however, to distinguish these from the third heart sound, which they closely resemble.

In the venous pulse tracing there is rarely any difficulty in making out several auricular (a) waves recurring at regular intervals. This is still easier in the electrocardiogram, for the P waves there are undisturbed by the undulation of ebb and flow, and stand out sharply marked upon the curve (Fig. 15).

Recently, studies by Gibson,⁴⁸ Thayer and Peabody,⁴⁹ and others have shown that in most cases of Adams-Stokes disease the vagi exercise a considerable influence upon the block, especially where the latter is not yet complete. In such cases the condition represented is: Block due to injured His bundle + block due to vagus action. In this case we are dealing with a double vicious circle.



In such cases as Gibson and Thayer have found, administration of atropine may cause lasting improvement or even disappearance of the block by removal of the vagal element, improving the circulation through the bundle and allowing it to recover a certain degree of its conductivity.

The association of ventricular extrasystoles with Adams-Stokes syndrome is quite common and may occur in two ways:—

1. Extrasystoles may arise in the slowly beating ventricle during complete heart-block (notably in the cases of Thayer and in one of the experiments of Erlanger and Hirschfelder).

2. Extrasystoles too weak to open the aortic valves may occur in a heart without any heart-block; and if two or three follow one another between the regular beats, they may give rise to pauses so long that the brain becomes anemic and the Adams-Stokes syncope sets in, as in a case reported by James, and in another recently observed at the Johns Hopkins Hospital.

Occasionally cases of extreme bradycardia (less than 35 beats per minute) have been reported in which a ventricular type of venous pulse was obtained with no trace of auricular contraction upon it. Mackenzie

believed that in such instances the cardiac impulse was originating in the auriculoventricular bundle, and termed them "nodal bradycardias"; but Lewis, as well as Thayer and Bond,⁵⁰ has found that in such instances the electrocardiogram revealed auricular fibrillation plus a complete heart-block.

Towards the therapeutics of heart-block, little has been accomplished. The problem of treating heart-block is a two-fold one:—

1. In partial heart-block, the aim should be toward diminishing the degree of block, and for this purpose atropine is indicated and digitalis distinctly contraindicated.

2. In complete block, once established, it is useless and may even be dangerous to try to restore conductivity. What is needed here is merely to quicken the rate of the independently contracting ventricles in order to maintain the circulation. Bachman has shown that this may sometimes be done by administration of strophanthin, a drug which itself diminishes conductivity. This drug, as well as other digitalis preparations, may, perhaps, by increasing the irritability and rhythmicity of the ventricles, prove valuable *in cases in which the block is already complete*, in spite of the fact that it is harmful in cases in which the block is partial. The degree of the block in each case should be carefully studied by graphic methods before it is used.

Electrocardiographic studies have also thrown light upon another type of partial heart-block, the partial interventricular block. Barker and Hirschfelder,¹⁰ had shown that cutting the left branch of the His bundle did not give rise to any block between the right and left ventricles or hemisystole. These results have been confirmed by Cohn and Trendelenburg,⁵² and by Rothberger and Eppinger. The latter observers have found, however, that when the left branch of the bundle is cut, the ventricular portion of the electrocardiogram assumes the form of right ventricular extrasystoles; and when the right branch is cut it assumes the form of left ventricular extrasystoles, although both ventricles still contract. The excitation evidently reaches the intact side of the heart first, and this determines the form of the electrocardiogram. By these criteria Eppinger and Stærck⁵³ have been able to diagnose correctly endocardial lesions affecting one branch of the bundle of His in two cases. That the criterion alone is fallacious was shown by a case whose electrocardiogram would correspond to that of a lesion in the left branch of the His bundle, which was recently under observation in the Johns Hopkins Medical Clinic, for no lesion of the bundle was to be found at autopsy. More cases of this type will have to be observed before the diagnosis can be made with certainty.

PART II.

THE FILLING AND EMPTYING OF THE HEART UNDER NORMAL AND PATHOLOGICAL CONDITIONS.

Very few of us have obtained from clinical observation of the patient a very clear idea of exactly how fast and to what extent the normal heart empties itself in systole, and whether that occurs as one sudden spurt at the beginning of systole, or as a uniform outflow throughout the systolic period. Nor have we, as a rule, a very clear idea of just how much residual blood there is left within the ventricles at the end of the systolic contraction, nor to what degree the amount of residual blood may vary before signs of cardiac weakness show themselves. On the other hand, our ideas of diastole have been equally hazy. We cannot learn from clinical observation, whether the ventricles are filled by a steady stream, or whether, as Harvey supposed, but little blood enters them until forced in by the active contraction of the auricles; nor do we know by any clinical evidence the exact position which the valves occupy in diastole. All these points are, as you shall see, matters which directly concern us in physical diagnosis and in treatment, but they cannot be made out by physical diagnosis nor even by examination with the fluoroscope and the orthodiagraph. They can be studied only by accurate registration of the change in volume of the heart.

Such records have revealed a good deal that is important in normal and in pathological conditions, and have thrown light (1) upon the causation of abnormal heart sounds, (2) upon the border-land between exercise and cardiac overstrain, (3) upon the interpretation of the functional tests of cardiac efficiency, and (4) upon their bearing on gymnastic treatment and hydrotherapy, and (5) lastly, have taught us much regarding the action of drugs and the indications for using them.

Our accurate knowledge concerning the filling and emptying of the heart may be said to date from the studies of Prof. Yandell Henderson,⁵⁴ (Fig. 16) of Yale in 1906. Henderson took a rubber ball, inserted a glass tube on one side, and cut a window on the opposite side large enough to slip the ball over the heart. He cemented a ring of thin rubber dam around the edges of the window, so that when the ball was slipped over the ventricles it fitted air-tight about the auriculoventricular groove, enclosing both ventricles in an air-tight chamber. When the glass tube is then connected with a large recording tambour, changes in volume of the ventricles may be recorded as rapidly as they take place. For comparison with pulse curves, it is a little more convenient to turn the tambour upside down, so that upstrokes indicate outflow from the ventricles, downstrokes indicate filling, and a level line shows that no change of size is taking place at all.

Henderson showed that if we record the volume curve of a rather slow heart, we find that the following events occur in the cardiac cycle:—

1. An instant (.03-.07 second) just before the aortic valves open, during which there is no change in size. This, as phonographic records teach, is the period of the first heart sound, and represents almost its entire duration.

2. Then comes the period during which the blood is forced out of the ventricles in a uniform spurt. This lasts about .25 second, until the end of systole. This is the period of the short pause between the heart sounds. As we shall see later, the normal heart does not empty itself completely in systole.

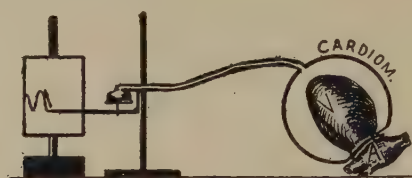


Fig. 16.—Device for registering changes in volume in the mammalian heart, showing the cardiometer (CARDIOM) in place with the rubber ring fitting tightly over the auriculoventricular groove. The recording tambour is inverted, so that upstrokes indicate diminution in the size of the heart. [From Hirschfelder's, *Diseases of Heart and Aorta*. Reproduced by courtesy of J. B. Lippincott Co.*]

3. At the instant that systole ends, aortic and pulmonary valves slap closed,⁵⁵ the second heart sound occurs, the mitral and tricuspid valves open, and the ventricles begin to fill. The pressure of blood in the auricles and veins drives the blood into the ventricles. This rush of blood fills the ventricles quickly, almost as quickly as they empty themselves in systole, and it fills them so completely, that when the pulse rate is slow the walls of the ventricle are stretched and the filling comes to an end some time before the auricle begins to contract.

4. There is, therefore, a period which Henderson terms "diastásis," in which little or no blood enters the ventricles, but in which it stagnates in the auricles and veins.

5. This is followed by the period of auricular systole, when the auricle contracts and pumps a very small amount of blood into the ventricle, usually less than one-fourth the total amount.

We can obtain a very clear picture of the filling of the heart by a very old and a very simple experiment which was devised by A. Baumgarten,⁵⁵ in 1843. If we obtain an ordinary calf's heart or pig's heart, and cut away the auricles so as to expose the mitral and tricuspid valves,

*The Publishers are also indebted to J. B. Lippincott Co. for permission to reproduce Figs. 71, 79, 117, 118, 131 and 132-I, from Hirschfelder's *Diseases of Heart and Aorta*.

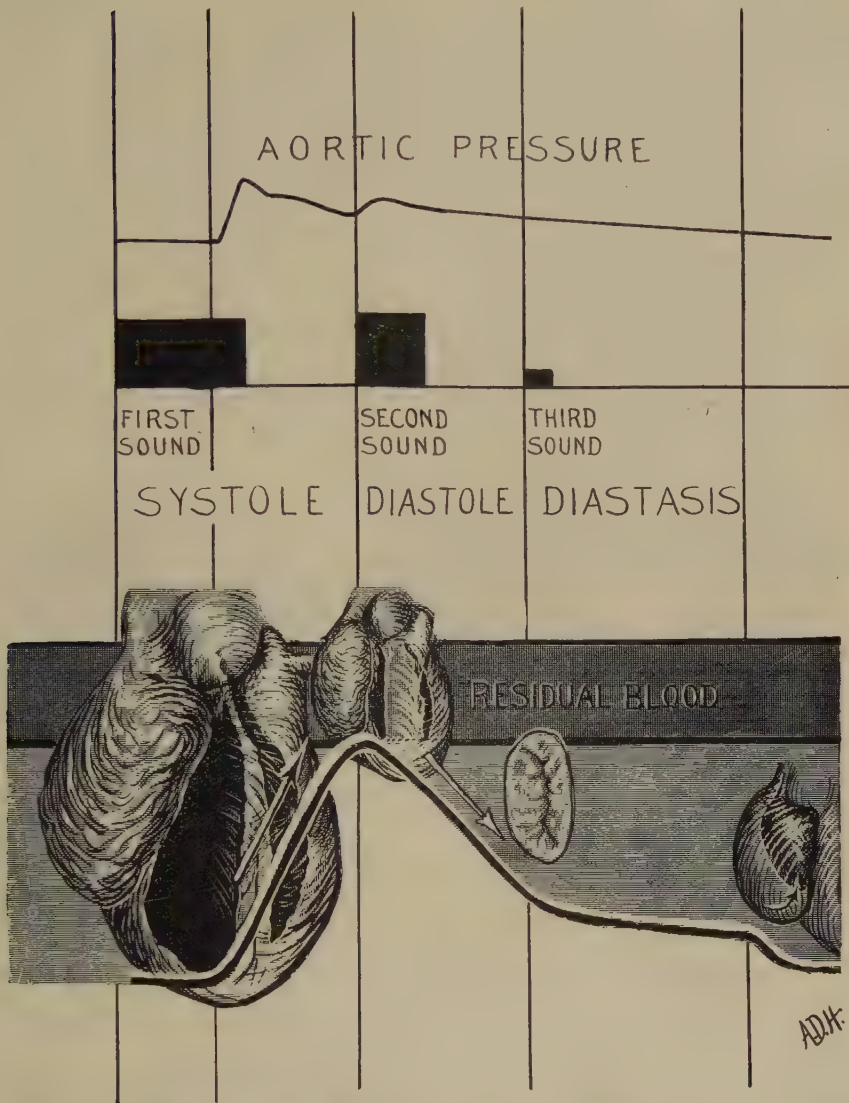


Fig. 17.—Diagram showing the events of a single cardiac cycle. The upper curve indicates the pulse in the aorta. The black rectangles indicate the incidence of the heart sounds. The hearts shown semi-schematically below indicate the relative volumes at different phases of the cardiac cycle corresponding to the normal volume curve which constitutes the lowest curve in the figure. These hearts are drawn by referring the corresponding points upon the volume curve to a common base-line, and taking the ordinates as the long axis of the heart. The changes in appearance are slightly exaggerated.

Downstrokes represent filling, upstrokes represent emptying of the ventricles. The sketch at the transition from diastole to diastasis represents the probable position of the mitral and tricuspid valves at that instant. The sketch at the right indicates the period of auricular systole. The heavily shaded zone indicates the amount of residual blood.

we can pour in water from a beaker above them and can watch the filling of the ventricles. If we pour it in slowly from a very small height, the ventricle is filled slowly and is not dilated by the inflow, and when filling ceases the valves remain widely separated. If we pour it in from a height of 10-20 cm., the ventricle fills more completely, and at the end of the influx the valves are found to be floated or slapped together along the greater part of the line of closure, and they are separated over only

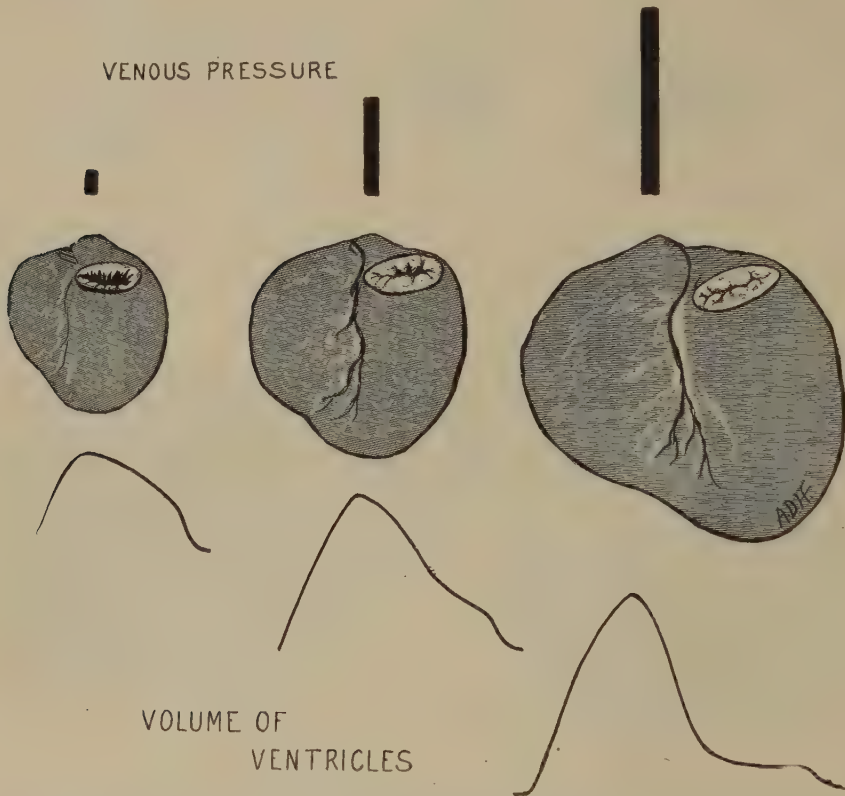


Fig. 18.—Diagram showing the effect of varying venous pressures upon the volume of the heart, upon the rapidity of filling of the ventricles (volume curve), and upon the position assumed by the mitral and tricuspid valves at the end of the first inflow into the ventricles. The figure to the left shows the valves remaining open, that in the middle shows partial closure (functional stenosis), that upon the right complete diastolic closure.

a small area. If we pour the water in from a height of many centimetres, the ventricle is overfilled and dilated by the inrush of the stream, and its walls are put upon the stretch, so that as soon as the inflow ceases the stretched muscle recoils and the valves are suddenly snapped together. This is exactly what occurs in the normal heart at the end of the rapid filling, especially in the heart of a young person or animal whose heart

walls have a high elasticity. Such a slapping together of the valves would naturally give rise to a recoil wave upon the pulse in the jugular vein, and in 1907, while examining a very athletic young man whose heart rate was slow, I encountered exactly such a wave upon the venous pulse.⁵⁶ I noticed that at the instant of this recoil wave (which I designated by the letter h), there occurred a very faint third heart sound, the sound of protodiastolic gallop rhythm; and I then suggested that both the wave and the heart sound might be due to this diastolic slapping together of the valves. The same explanation was given independently some months later by Gibson⁵⁷ and Thayer,⁵⁸ and Einthoven⁵⁹ has recorded such a sound with the microphone, and finds that it occurs 0.18 of a second later than the second sound, at exactly the instant when it might be expected from the shoulder on the volume curve. Quite recently I had further confirmation of this while examining a man, whose left chest wall was removed for empyema, and whose left ventricle therefore expanded and contracted just under the skin. The emptying and filling and the diastasis lasting $2/5$ of a second, could be easily seen; and a definite third heart sound could be heard at the apex at the very instant that filling of the ventricle became complete.

The third heart sound is very soft and distant, not louder than the tick of a watch, and sometimes has a slightly rumbling character. It is very easy to miss unless one is listening particularly for it, determined to catch the faintest possible sound,—and then its detection is quite simple.

Thanks to Thayer, we know now that this third heart sound is a normal and frequent occurrence. It is met with in 50 per cent. of all normal individuals, and between the ages of ten and twenty it is found in 85 per cent. It is most frequently heard at the apex when the subject is lying on the left side, but very often is heard over both ventricles or indeed, over the whole precordium.

Now, I do not wish to leave you under the impression that I believe that the mitral and tricuspid valves are always completely closed during the greater part of diastole; the same experiment, which shows that the cusps close, shows equally well that unless the valves are closed very tightly they quickly reopen at least one point along the line of closure.

The exact position which they assume depends upon various factors. If one pours fluid into the ventricle from a height of 2 to 5 cm. the cusps remain open throughout. If one pours it in from a height of 10-20 cm., they close everywhere except at one small area near the middle. *There is a functional stenosis.* If one pours it in from a much greater height, they snap entirely together. The functional stenosis of the mitral orifice can be produced also whenever there is a certain balance between the pressure in the auricle and the pressure in the ventricle. This reaches its ideal condition in aortic insufficiency, in which the intraventricular pressure during diastole may be relatively high and require a forcible auricular contraction of the auricle to overcome it; and a thin stream

is forced through the narrowed orifice downward toward the ventricle. In aortic insufficiency the jet of blood regurgitating from the aorta often strikes forcibly against the anterior cusp of the mitral valve, and by its impact pushes it over into the mitral orifice, thus adding to the forces which tend to produce a functional stenosis (Hirschfelder⁶⁰).

The presystolic murmur, ordinarily known as the Flint murmur, which is so common in aortic insufficiency, but so transitory in its duration, might easily be caused when a functional stenosis of the mitral is produced by such a balance between the pressure within the ventricle and that within the auricle. It is, indeed, interesting that Austin Flint,⁶¹ himself suggested the possibility of such a functional stenosis; but, as he gave no evidence to show how it might occur, the suggestion gained no credence.

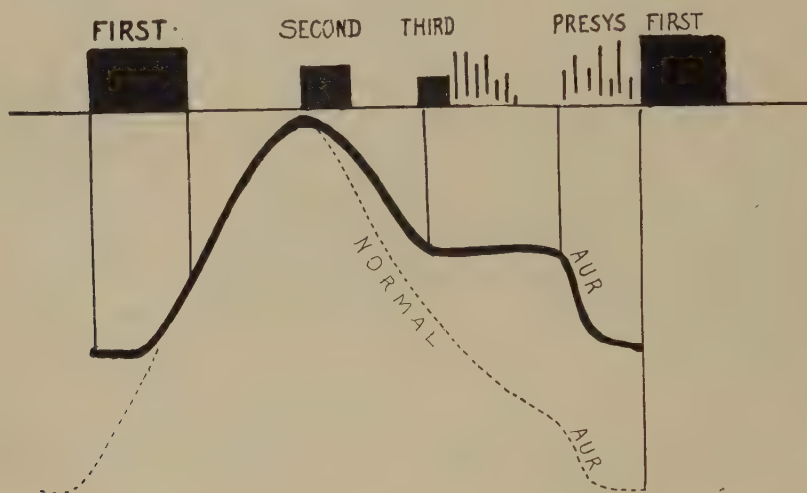


Fig. 19.—Volume curve in experimental mitral stenosis and its relation to the heart sounds and rumbles. The light broken line indicates the normal volume curve. The first heavy line indicates the volume curve in mitral stenosis; the shaded black rectangles indicate the first, second, and third heart sounds, the shaded portion indicates the middiastolic and presystolic (PRESYS) rumbles. AUR indicates the period of auricular systole.

Moreover, in aortic insufficiency we find loud third heart sounds and middiastolic rumbles, all phenomena which are in accordance with this theory of the diastolic approximation of the valves.

In mitral stenosis, on the other hand, we have a different phenomenon. Here we have to deal with three kinds of sounds in diastole; a rather early and loud third sound or protodiastolic gallop rhythm, a middiastolic rumble, and a presystolic or auriculosystolic crescendo murmur. If we produce an experimental stenosis of the mitral orifice we find that the form of the volume curve changes. Less blood enters the ventricle in early diastole and the stagnation in diastole sets in earlier. Correspond-

ing to this there is a very early protodiastolic sound or third heart sound, and if the valves are thickened it is louder and more distinct than usual. Indeed, it was just in mitral stenosis that this sound was first described by Bouillaud in 1835 as the *bruit de rappel* or "echo sound."

This sound is often prolonged into the middiastolic rumble. Potain and Sansom thought that both the sound and the rumble are due to an "opening snap" of the mitral valve, but it appears to me more likely that it is a "closing snap" accompanying the diastolic closing or partial closing of the valve. James Mackenzie⁶² calls attention to the fact that we can differentiate this middiastolic rumble from the presystolic, by the fact that it is decrescendo in character, while the presystolic, or as Gairdner termed it, the auriculosystolic rumble, due to contraction of the auricle, is crescendo in character.

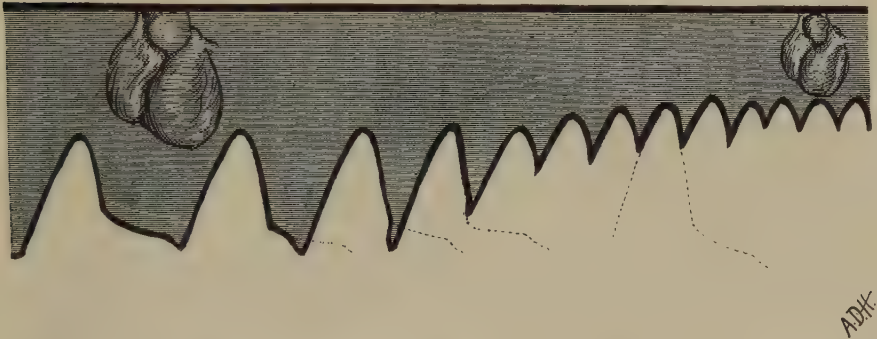


Fig. 20.—Volume curves of the ventricles at increasing pulse rates. The shaded zone indicates the amount of blood within the heart at each instant, the sketches at right and left indicating the size of the heart pictorially. The light broken line indicates the volume curve as it would appear if the heart rate were slow.

These I think may show you some of the points in which studies upon the volume curve have been of use to practical physical diagnosis. I shall now turn to the more practical side and show their bearing on the observation and course of the disease.

Henderson has shown that, under most normal conditions, practically the same volume curve of which we have spoken is met with at all heart rates, except that as the rate becomes more rapid, the period of diastasis is shortened and finally is cut off entirely, so that the cardiac cycle then consists of the full period of outflow and the full period of rapid inflow and the period of auricular pumping. You will notice that although the rate is quickened the heart fills as much as before, each beat throws out as much blood as it did before, so that the total blood flow per minute is increased. If the rate is increased a little more, the diastolic filling is encroached upon and less blood has time to enter the ventricle, so that

correspondingly less blood is forced out. Within the normal rates, however, this diminution in filling is proportional to the pulse rate, so that the product of outflow by rate is constant. That is, for example, at a rate of 60 the heart might pump out at each systole twice the amount of blood pumped out at a rate of 120, so that the amount of blood flowing through the aorta per minute in both cases would be the same. However, as the rate becomes too fast, the tonus of the heart muscle plays a more important rôle and prevents the proportionate filling, so that it does not have time to fill, and consequently cannot drive out enough blood with

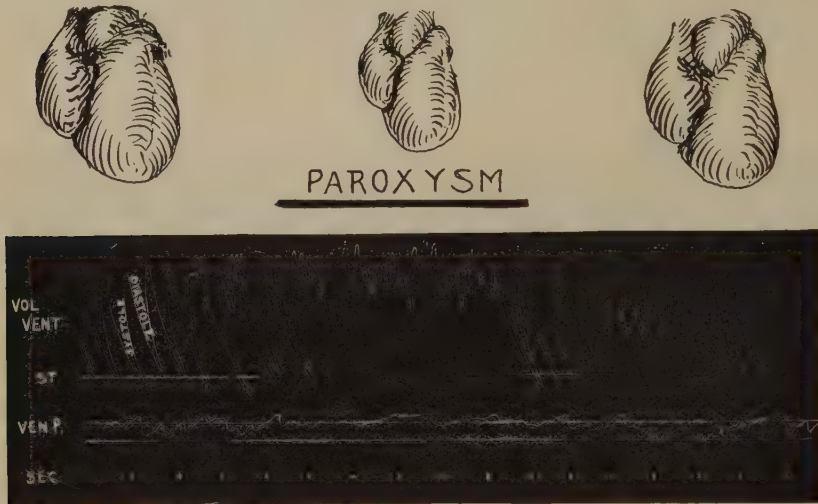


Fig. 21.—Diminution in the volume of the ventricles and rise of venous pressure in experimental paroxysmal tachycardia. Vent. Vol.=volume of the ventricles; Ven. P.=venous pressure; St.=stimulation of the auricles with induction shocks. Sketches above indicate size of heart at the corresponding period, as indicated by the volume curve referred to its base-line. This semidiagrammatic representation slightly exaggerates the apparent change in size of the heart. (Illustration from author's article, *Arch. of Int. Med.*, Vol. VI.)

which to keep up the circulation. We have then two forms of failure of the circulation from mere changes in rate:—

1. Slowed circulation from too slow heart beat with a large heart—bradycardia—of which we have evidence in the syncope of Adams-Stokes disease.

2. Slowed circulation from too fast heart rate with a small heart—tachycardia—of which we have occasional examples in the syncope that occurs in paroxysmal tachycardia and in the fainting of athletes.

You will see in the tracing an example of this shrinkage of the heart in a dog during the course of an experimental paroxysm of tachycardia from stimulating the auricle until fibrillary contractions of the auricle have set in; and you will notice that with the onset of the tachycardia

the heart becomes much smaller—and the venous pressure rises, which shows that the blood cannot enter the ventricles because it has not time to do so. The circulation fails because the heart is underfilled. He believes that when the carbon dioxide of the blood falls below normal on account of too rapid breathing or of fever or acidosis, fluid leaves the vessels and passes into the tissues. The vessels thus become emptied just as they are emptied from hemorrhage, and pressure in the veins falls to so low an ebb that the heart is not well filled but remains much smaller than normal. Its contractions also are smaller, and so little blood is sent out into the arteries that the latter are not overfilled and the arterial pres-

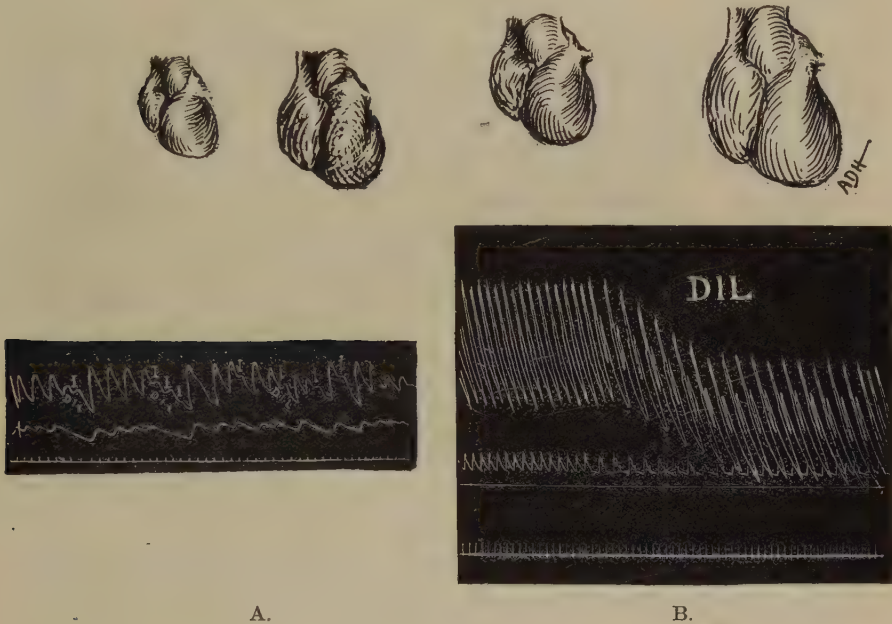


Fig. 22.—Effects of producing an irregular rhythm upon the volume of the ventricles.

A—Extrasystolic irregularity produced by repeated induction shocks. I, I, I, ineffectual extrasystoles too feeble to force the aortic and pulmonic valves open. DIL, dilatation of the ventricles.

B—Continuous bigeminal rhythm due to the entrance of a bubble of air in the right auricle showing the great dilatation of the ventricle as a result of the irregularity. (Kindness of Dr. P. D. Cameron.)

sure falls in consequence. These views are somewhat at variance with the theory of vasomotor failure which Romberg and Pæssler,⁶³ Crile,⁶⁴ and others have advocated, but Henderson,⁶⁵ has been able to produce the whole group of conditions by over-ventilation of the lungs, and he has shown that the heart and most of the vessels are smaller in shock than at other times. Seelig and Lyon, on the other hand, have shown that the viscera contain less blood in shock than under normal conditions.

We find the same condition—namely, the underfilled heart, clinically in many cases when we examine the heart with the orthodiagraph or percuss its outlines very carefully. We also find these conditions in enteroptosis in which, just as Leonard Hill has shown upon the rabbit, which stands on its hind legs, the blood gravitates into the abdominal veins and does not fill the heart, in many patients during attacks of paroxysmal tachycardia, and in some cases of neurasthenia with manifestations of cardiac weakness, and, as Dietlen and Moritz⁶⁶ have shown, in some cases of syncope from overexertion. Of the two latter conditions, the primary condition may be a too rapid respiration washing the CO₂ out of the blood and thus giving rise to *acapnia* and underfilling of the heart.

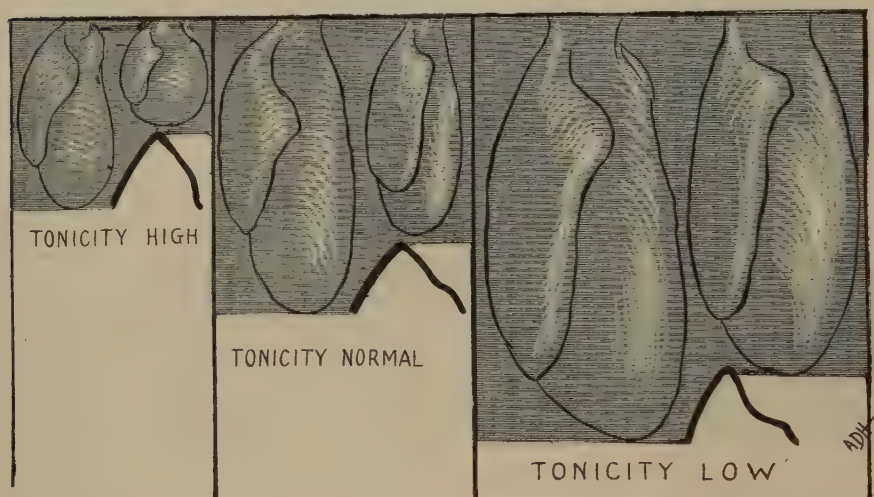


Fig. 23.—Diagram showing the condition of the heart with varying degrees of tonicity but with systolic output (amount of blood forced out per beat) normal. The volume at the end of diastole constitutes the index of tonicity which at the end of systole indicates the amount of residual blood.

The production of a simple irregularity by means of induction shocks brings on dilatation of the heart.

This question is at present in its infancy, but no doubt before long it will gain a very wide clinical importance.

We now come to consider what light a study of the volume curve can throw upon the work of the heart and upon the action of drugs. In order to do so, however, we must digress for a moment to consider the property known as the tonus of the heart muscle. *The tonus or tonicity of cardiac muscle is its tendency to resist overstretching during diastole, or in other words, its diastolic rigidity.* It is this tendency which keeps the heart from distending, and which antagonizes the effect of the venous pressure; and it is thus by virtue of the tonicity that the period of active filling of the ventricles ends and diastasis is enabled to set in.

When the venous pressure is constant, we may therefore measure the tonus quantitatively by determining the volume of the heart at the end of diastole. As you see upon the diagram, we may have a heart with a normal systolic output and a normal amount of residual blood remaining in the ventricle at the end of systole. This, I may add, is quite a considerable amount and varies greatly in different hearts and under different conditions. Now, we may also have a heart with a low tonicity which fills to a much greater degree than the normal heart. If this forces out the same amount of blood at each beat, you can readily see that a larger

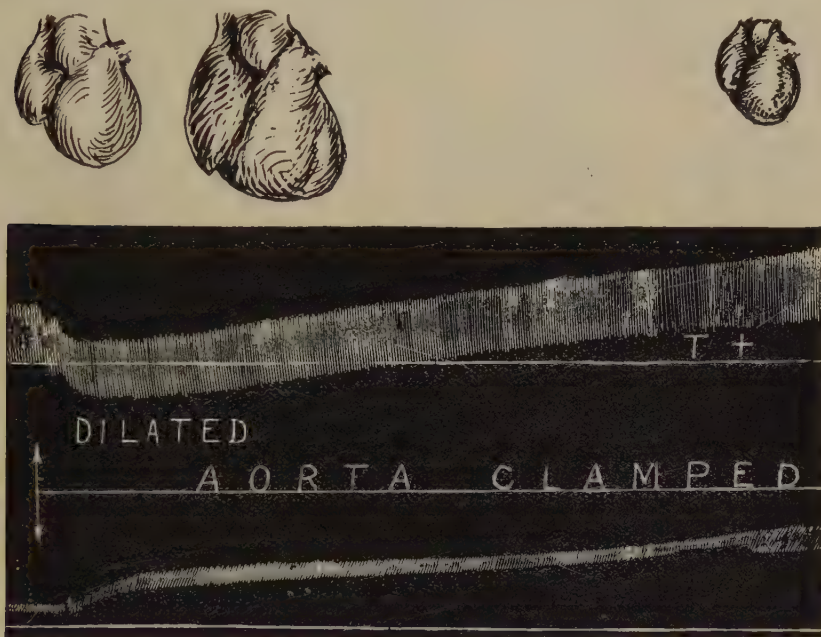


Fig. 24.—Effect of clamping the thoracic aorta upon the volume of the ventricles and upon the blood pressure in a dog with a strong heart whose tonicity is high. The volume of the heart after a momentary dilatation, gradually becomes smaller than before the clamping of the aorta. The relative size of the heart at each stage shown diagrammatically in the sketches above. These are drawn as in Fig. 2, and hence represent slight exaggerations of the actual appearance of the heart in these stages.

amount of residual blood will remain in at the end of systole, sometimes several times the amount put out at each beat. Such a heart with low tonicity may bail out this excess of residual blood by a larger output per beat; but if the tonus, the heart rate and the venous pressure remain unchanged, it will fill again to the same extent at each diastole. On the other hand, if the tonus is increased above the normal, less blood enters in diastole and with the same systolic output the heart bails out the residual blood until it contains much less than normal.

You see also from the curves that a heart with high tonicity fills more slowly than normal, while one with low tonicity fills more rapidly. In their effects a high tonicity and a low venous pressure are equivalent, and so are a low tonicity and a high venous pressure.

After this digression we shall now return to consider how these facts enable us to study overstrain of the heart. The effect of increased strain upon the heart may be studied by clamping the thoracic aorta. The effect which one then obtains depends upon the condition of the heart. If the heart is strong and the tonus of its walls is good, we obtain the effect shown by the tracing. The heart dilates for a moment under the strain, but soon the extra load begins to act as a stimulus to the ventricles, and they begin to pump out more blood at each systole. In a very short

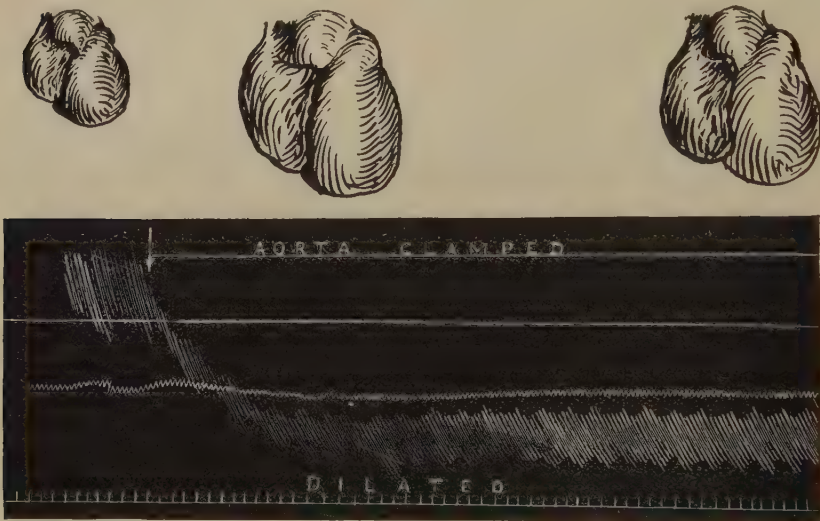


Fig. 25.—The same experiment performed upon a weak heart with low tonicity. The heart remains dilated throughout the strain. The blood-pressure at first rises, then falls.

time, as you see, the ventricles bail themselves out to the original volume, the systolic output and the tonus increase. Owing to these factors, however, the diminution in size of the ventricles continues. The residual blood is bailed out of the ventricles and does not re-accumulate, and, in spite of the continued strain, the ventricle becomes much smaller than it was before the strain was placed upon it. Indeed, in this particular heart the diminution in size continued to a much greater degree than is shown in this part of the tracing, until the lever actually kicked over the top of the smoked paper!

This experiment shows us two things: 1. This good strong heart which was capable of responding to strain, and which was of normal appearance at the beginning of the experiment, nevertheless, contained

residual blood which amounted to more than twice the output at each beat. 2. A mild strain upon a strong heart stimulates it, increases its tonus, and causes its volume to decrease just as a proper load serves to strengthen the contraction of a skeletal muscle. If the heart is just a little too weak, however, the same strain has a different effect. The next curve is taken from an animal with a weaker heart, and you will notice that here the strain diminishes the cardiac output and the tonus, and the heart remains dilated after the strain. This strain was distinctly harmful to this weaker heart, while in the case of the stronger heart the same strain was beneficial.

Fig. 26 shows the effect of a bicycle ride, from Leipzig to Strasburg, upon the heart of a trained rider.

Here we have illustrated the principles which are involved in all our gymnastic and hydrotherapeutic treatment in heart disease. A strain which is light stimulates the heart at once to stronger contractions and



Fig. 26.—Semischematic representation of the orthodiagraphic outline of the heart of a trained bicycle rider before, just after, and four weeks after a bicycle race from Leipzig to Frankfurt. (After Moritz and Dietlen.)

to improved tonicity; a strain which is too great, though perhaps only a little too great, weakens and dilates it. The border-line is easily crossed. It is this, too, that renders the exercise treatment and the bath treatment of heart disease a dangerous weapon. The exercise treatment depends upon the assumption that a more or less mild exercise will stimulate the heart to increased output and that it will improve the tonus of the heart muscle, just as we see clamping the aorta does it in the dog with the strong heart. Now this is the case if the heart is strong enough to stand any added strain. If it is not, the heart dilates just as we have seen in the other dog, and the dilatation may even go on to the point of complete heart failure and death. Most of us probably know of patients that were barely able to keep alive who have taken the Nauheim treatment and have died under it. The hearts of these patients were too weak and their tonus too low to respond to further strain, so that in them the exercise treatment had the exact opposite physiological effect from that for which it is indicated; whereas, the same treatment or any gentle, but less formal exercise might be quite beneficial to a stronger heart with more reserve force.

The CO₂ bath treatment gives rise almost to the same form of strain upon the heart as is produced by exercise. It stimulates the skin and causes the blood-vessels to relax, and also brings about an increase in the output of the heart at each beat. The blood-pressure may or may not be affected; it sometimes falls, but it often rises. Anyone, who has himself taken a Nauheim bath, realizes that it is almost as fatiguing as a mile walk, and should accordingly be used with great discretion.

Apparently that is the trouble with the Nauheim treatment as given at Nauheim and elsewhere. The physicians have become so hypnotized by the one idea or by the income which it has brought them, that they put all patients into one group, and thus violate all the physiological principles upon which their treatment is based.

Our experiment also throws some light upon another matter of clinical importance—namely, the so-called functional tests of cardiac efficiency. The most popular of these is Græupner's exercise test, in which it is found that the blood-pressure of strong hearts rises during exercise, while the blood-pressure of weak hearts falls. You will notice, however, in the curves (Figs. 24 and 25), that when strain is placed upon the heart—the strong heart as well as the weak heart—there is a rise of blood-pressure which lasts for a while in both, in spite of the fact that the hearts are dilating. In this particular weak heart the blood-pressure falls after a while. In many cases, however, the period during which the blood-pressure remains high in spite of dilatation is much more prolonged, so that from changes in blood-pressure alone one could not distinguish between the stronger and the weaker heart. The patient with a moderately weak, but not absolutely failing heart usually responds with a much greater rise of blood-pressure than does the normal individual. On the other hand, the athlete responds to mild exercise with a fall of pressure. The change of blood-pressure, therefore, gives no true index of the dilatation of the heart, nor of the degree of cardiac tonicity, and therefore, the mere blood-pressure and pulse-rate changes furnish evidence which is insufficient for the estimation of cardiac efficiency. The symptoms and sensations of the patient, his manner of breathing, his change of color, his general appearance, the degree of fatigue and many other signs, furnish a much more delicate test than the numerical changes in pulse rate or blood-pressure.

It is evidently of great importance to know the exact action of drugs upon the tonus of the heart muscle. The classical studies upon heart stimulants had taken into account only the action upon the blood-pressure, and with the exception of a few studies upon the frog's heart the changes in tonus had not been studied. For example, all the pharmacologists had stated that strychnine acts upon the vasomotor centre, but has no action upon the heart itself. Clinicians have, from time immemorial, been giving strychnine in order to increase the tonicity of

dilated hearts. Accordingly in 1907, I suggested to Dr. Cameron,⁶⁷ who was working upon his doctor's thesis for the University of Edinburgh in the Physiological Division of the Johns Hopkins Medical Laboratories,

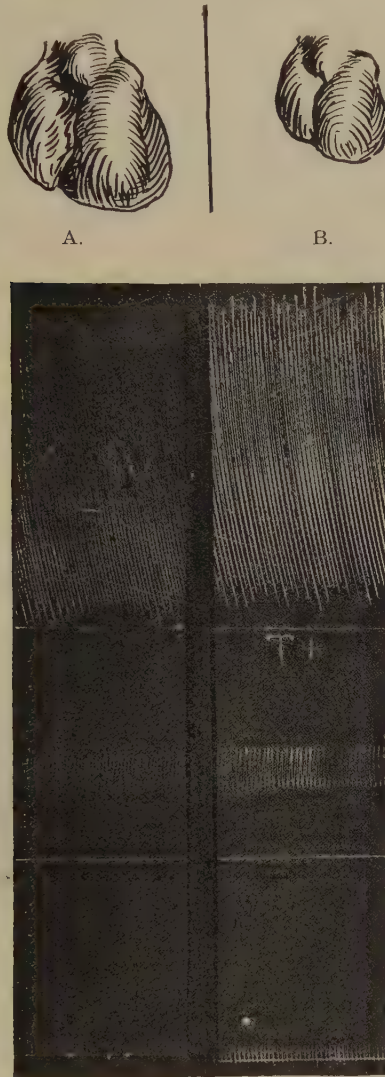


Fig. 27.—Effect of intravenous injection of strychnine upon the volume of the dog's ventricles. (Kindness of Dr. P. D. Cameron.) A. Before injection; B, after injection.

T+, tonicity increased. The sketches above indicate the size of the heart.

to test the effect of strychnine upon the volume of the dog's heart, especially using doses which were comparable to doses used by clinicians. Dr. Cameron found in a large series of experiments that strychnine, as

you see in the tracing, caused a diminution in the size of the heart, whether the output per beat were increased or not, and whether or not there was any appreciable change in maximal blood-pressure. In other words, strychnine does increase the tonus of the heart muscle; and it may be regarded as a direct heart stimulant and useful for dilated hearts. On the other hand, if Henderson is correct in his view that in shock the tonus of the heart is already too great, strychnine would be directly contraindicated in this condition, and indeed in all conditions associated with an underfilled heart. It is a little too early to take this view dogmatically; but we must remember that even Crile and Cushing regard strychnine as harmful in cases of severe shock in which they assume that the vasomotor centre is fatigued.

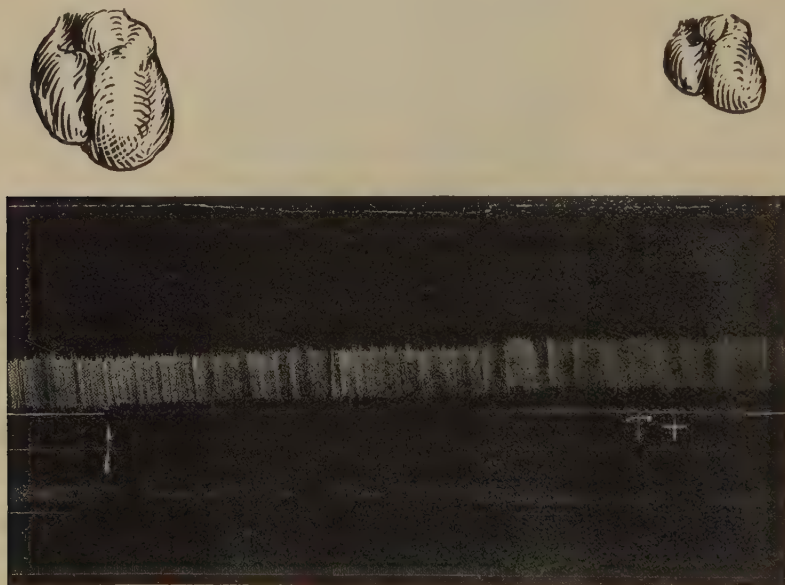


Fig. 28.—Diagram showing the effect of injection of digitalis upon the volume of the ventricles. (Kindness of Dr. P. D. Cameron.)

Digitalis injected at the point indicated by the arrow. +, tonicity increased.

The same action upon cardiac tonicity, which we have just shown for strychnine, is possessed also by digitalis and strophanthus to a much higher degree. All these drugs act by stimulating certain nerve fibres which run to the heart through the vagus, and which have a separate action in controlling tonicity. Hoffmann,⁶⁸ has found that in the frog these nerves exist as separate trunks, the so-called septal nerves which run from Remak's ganglion along the septum to Bidder's ganglion at the auriculoventricular ring. They thus reach the ventricle and stimulate it directly, cause an increase in its tonicity and strength of contraction. Dr. Cameron found that if the vagi are paralyzed with atropine, strychnine,

digitalis, and strophanthus, even calcium and potassium no longer cause any change in tonicity whatever. The combination of digitalis and atropine, which has been recommended by some clinicians, is therefore contraindicated.

Another condition in which a study of the volume curve has been of practical importance for treatment is aortic insufficiency. Ever since Corrigan,⁶⁹ in his classic paper in 1837 put the ban on the use of digitalis in aortic insufficiency for fear of promoting regurgitation by prolonging diastole, this drug has been viewed with suspicion and recommended with caution. In 1906, I suggested to Stewart⁷⁰ to study the pulse form and heart volume in experimental aortic insufficiency by means of the Henderson cardiometer; and much to our surprise we found that the important factors in determining the amount of regurgitation were not the rate

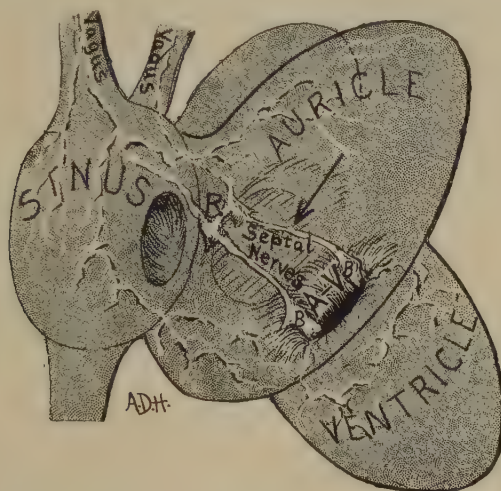


Fig. 29.—A diagram showing the course of the nerves in the frog's heart. The nerves over the sinus and auricle influence the rate, the nerves in the septum influence the tonicity and force of the ventricles.

R, Remak's sino-auricular ganglia.

B, Bidder's auriculoventricular ganglia.

A-V, auriculoventricular muscle.

of the heart, but the tonus of the heart muscle and the peripheral resistance of the arteries. We had expected that when the heart was slow it would dilate continuously throughout diastole, just as Corrigan supposed; but the tracings, as you see, show that when the heart is strong and the tonus high the filling becomes complete, even more rapidly than does the normal, and then no matter how long diastole continues no more blood enters. Indeed, if the tonus is high the regurgitant blood actually acts as a stimulus to the heart muscle, the tonus increases and the residual blood diminishes, so that the heart, after the production of the leak, is actually smaller than under normal conditions. However, if the tonus

is low or if the resistance is high, the heart does continue to fill throughout diastole and becomes dilated. Increasing the peripheral resistance, we found did under all circumstances increase the amount of regurgitation.

The question as to the usefulness or harmfulness of digitalis depends upon whether its action on the tonus of the muscle outweighs its tendency to constrict the blood-vessels, or whether the harm done by constriction of the vessels outweighs the advantage gained by increased tonicity. My own clinical experience leads me to believe that the advantage outweighs the disadvantage, and this view has been strengthened by a brilliant series of experiments by Cloetta.⁷¹ Cloetta showed that treating normal rabbits with digitalis for several months had no effect upon their hearts

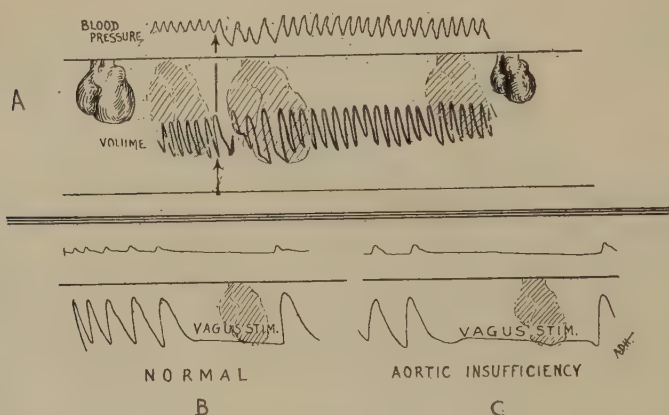


Fig. 30.—Effect of aortic insufficiency upon the volume of the ventricles (modified from Stewart, *Arch. Int. Med.*, 1908, I.).

A. Effect of producing an aortic insufficiency upon the heart of a very strong dog. Upper curve, blood-pressure, lower curve, volume curve of the ventricles. One of the aortic cusps was punctured at the point indicated by the arrow. The diastolic blood-pressure fell at once, the systolic remained unaltered. There was a momentary dilatation of the ventricles followed by a gradual diminution in size, as indicated by the sketches.

B. Volume curve of a normal heart under vagus stimulation, showing prolonged diastasis.

C. Volume curve from the same heart after the production of aortic insufficiency, showing the same result from vagus stimulation. The filling of the ventricle ceases as early as in the normal condition. The heart is very slightly more dilated than before the production of the lesion.

or vessels. He also produced aortic insufficiency in a large series of rabbits, treated one group and left the other group as controls. He found that the hearts of the treated rabbits were much more dilated and almost twice as much hypertrophied as the controls, and that the aortas of the controls were much more dilated than those of the treated rab-

bits. Moreover, the hearts of the treated rabbits were capable of much greater strain than were the controls. The digitalis had done good.*

However, in human aortic insufficiency, especially the arteriosclerotic type, we are confronted with an abnormally high peripheral resistance. It is advisable to lower this resistance as much as possible so that if one gives digitalis it is advisable to give the nitrites as well, especially sodium nitrite or small doses of erythrol tetranitrate.

The best substances of the digitalis series for acute failure are unquestionably strophanthin or ouabain, since they can be obtained in crystalline form and do not cause vaso-constriction. But we must never forget that strophanthus preparations must not be administered by mouth. Hatcher and Bailey,⁷² have shown that their absorption by the digestive tract is uncertain. When given by mouth one may fail to get any effect, or may suddenly get a toxic effect. Subcutaneous administration leads to pain and often abscess. Intravenous administration of a sterile solution is very satisfactory, especially in an emergency, but if a little gets outside of the vein it is painful. The best by far, in spite of some pain occasionally, is to give the drug deep into the muscle and massage for some time.

Dr. Cameron has found also that amyl nitrite and nitroglycerine have a direct action upon the heart and increase the tonus of the muscle and the systolic output. The latter effect has been found in man by Hewlett,⁷³ and by myself, so that both these drugs are of use in acute heart failure of aortic insufficiency. Indeed, in my experience they do more to relieve cardiac asthma of aortic insufficiency than any other drug. I may add that the same action on tonicity, that is in relieving dilatation, may account for the relief which they give in attacks of angina pectoris, particularly since Bond⁷⁴ in my laboratory has found that under ordinary circumstances they decrease rather than increase the flow through the coronary vessels.

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ON CHRONIC ENDOCARDITIS REGARDED AS A FIBROSIS
OF THE VALVES OF NON-INFECTIVE ORIGIN.

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In these days when bacteriology is dominant, if not indeed rampant, it is difficult to rid ourselves of the idea that fundamentally underlying one or other morbid condition of the tissues there is some primary microbic factor. Or perhaps, more accurately, our first inclination is to search after and seize upon evidences of present or past microbic activity, and, if we can find indications which with greater or less plausibility can be regarded as suggesting the outcome of microbic growth within the tissues, then we are satisfied to believe that we have grasped the etiology of the condition. If, on the other hand, we find ourselves compelled to fall back upon physical or metabolic factors as causes of tissue change, we do this with a certain distrust or discontent. For example, we have nowadays to accept such conditions as myxedema, acromegaly, Addison's disease, obesity, gout and acidosis as the resultants of disorders of the internal secretions or more broadly of cellular metabolism. But doing this, confessedly, it is difficult to form a mental picture of the succession of changes in the cells and tissues that lead to the anatomical manifestations of these different states. On the other hand, we have been drilled so thoroughly into an appreciation of the various stages which may result from an infective inflammation, and those stages, it may be added, are so many and so varied, that it is easy for us to imagine almost any morbid process as a resultant of some form of infection. Thus in the matter of valvular disorders—of endocarditis—I think I make a correct statement in saying that our tendency is to regard the valve changes as outcomes, whether recent or late, of some infective process, and, whether voluntarily or involuntarily, we find ourselves sceptical as to explanations of any other order.

Nevertheless, are we justified in considering chronic endocarditis as essentially of microbic origin? For myself, I must acknowledge that very early in my career a series of experiments by my old chief, the late Professor Roy, of Cambridge, published in our joint names, gave me food for thought. Among pathologists there has been no more brilliant mechanical genius than was Roy. His ability to devise instruments fitted to give records of one or other order was extraordinary. He devised and I noted. And incidentally in the course of our studies upon the effects of increased arterial pressure upon the volume and work of the dog's heart we found, that increased aortic pressure, produced by narrow-

ing the aorta was repeatedly followed by very definite changes in the aortic valves. These, we found, were not mere inert mechanical membranes, but reacted to their environment. The aortic cusps, it may be recalled, are normally devoid of vessels save near their bases. Their nourishment therefore is by means of blood plasma absorbed through or between the lining endothelial cells, or both, from the cardio-aortic blood. After extreme high pressure in the first part of the aorta we found that the cusps presented a series or chaplet of fine glistening bead-like elevations just below the line of their apposition. Evidently during diastole the high pressure acting upon their aortic aspect coupled with the low pressure on their ventricular aspect, and it may also be with expansion of the endothelial cells and increase in the intercellular spaces due to stretching of the cusps under the increased pressure; all these have led an increased percolation of "lymph" into the valve substance with a collection of the same along the line of greatest strain or weakness of the cusps. And Roy and I then called attention to the possibility that the thickening of the aortic valves in cases characterized by high blood-pressure might be a later outcome of this same process.

Now chronic endocarditis in elderly people is characteristically associated with the presence of nodose arteriosclerosis, and the two processes are, I would point out, of identical type. Both conditions involve intimal structures, (for the heart valves are but infoldings of the cardiac intima), and, histologically, they are of the same order, with overgrowth of the subendothelial connective tissue, the most recent layers being nearest the surface, the deeper layers exhibiting a series of degenerative changes which culminate in the development of calcareous plaques. I freely admit that in one order of arteriosclerotic changes a proliferation and swelling of the cells of the musculo-elastic layer, immediately to the inner side of the internal elastic lamina is a prominent feature. In the cases that I here refer to these changes while they may be present are not dominant. What is especially significant is this laying down in an orderly manner of layer after layer of connective tissue parallel to the surface, whether of aorta or of aortic cusp. There are here none of the cardinal signs of inflammation or its after results; no accumulation of leucocytes or plasma cells, no entry and no formation of new vessels, such as we see, for instance, after the chronic inflammation of other non-vascular regions, as the cornea. As my old colleague, Professor Klotz, has demonstrated (although he does not see eye to eye with me in the explanation of these changes) a similar uniform connective-tissue hypertrophy with accompanying overgrowth of the musculo-elastic layer can be produced in the rabbit by purely mechanical means, namely, by periodical raising of the blood-pressure for a few minutes every day extending over several months. In the absence, therefore, of adequate evidence of infective origin in these cases, in the absence of signs of ordinary inflammation and from the histological features of the new tissue, it is neces-

sary to look for some other non-microbic, causative agent in the production of these two conditions, and I cannot but conclude that in both we deal with stress or perhaps, more accurately, strain upon the affected part, coupled with adequate, or indeed increased nutrition; I say *strain* rather than *stress*, regarding the latter as the normal condition to which the vessels are normally and periodically subjected. *Strain* I regard as a more abnormal pathological condition leading to one order of conditions of the nature of increased reaction, and *overstrain* as a still more aggravated condition having, however, results of a different nature—namely, to absence of reaction. What seems to me characteristic of all the conditions, here referred to, of valves and arteries is that either we have clinical indications that the tissues are already weakened, so that what under normal conditions would be a stress, now becomes a strain (where it does not become an overstrain), or, on the other hand, that the tissues in the intima are in their normal state, but are subjected to increased blood-pressure, to an actual rather than a relative strain.

There is, it may be laid down, a normal environment for the cells of every tissue under which those cells attain unto a certain limit of growth and do not exceed this limit so long as environment remains unchanged, but, at the same time, it has to be recognized that even such inert tissues as bone show us clearly an increased growth under conditions of moderate increase of the work they are called upon to perform. For example, increased muscular exercise demonstrably leads to increased weight and size of the skeletal bones, and development of their bony ridges where these muscles are inserted. And so with the intima of the aortic cusp: subject this to a moderate strain and it undergoes thickening. The prettiest example of this that I have come across has been in three cases of functional incompetence of the aortic valve, through widening of the aortic ring. All three of these cases were relatively early; under the hydrostatic test each exhibited a roughly-triangular orifice where the three corpora Arantii did not meet, and it was very striking to notice that just at this region the edge of each cusp had undergone thickening and rounding, with distinct fibrosis. The cause here was purely mechanical; just those portions of the cusp that did not come into apposition were subjected to the greatest strain, and, as a consequence, the cells had proliferated and produced increased fibrous tissue.

But it may be objected that in the case of the mitral valve, for example, in the typical endocarditis of the young individual, due to rheumatism, we have evidence of the same fibroid thickening of the valve which is of undoubted microbic origin, since everyone nowadays either believes, or is prepared to believe, in the infective nature of acute rheumatism.

It is quite true that these cases so far as we can follow them, (where death occurs in the acute condition), begin with indications of a true inflammation, with destruction of the endothelium, formation of vege-

tations, as also vascularization of the valve. The early stages here are identical to all intents and purposes with those following upon an acute microbic ulceration of the cornea.

Now I wholly admit this infective origin of these mitral cases and, indeed, also of a certain proportion of cases of aortic endocarditis. I would only urge, however, that *the progressive thickening and contraction of the mitral valve is an interval occurrence, and is not directly due to the microbic irritation*. I am inclined to believe, that whether by the deformity of the valve produced in the region of actual ulceration, or merely through the focal growth of the micro-organisms, the valve becomes weakened and no longer functions so perfectly as before; and, as a consequence, is subjected to a relative strain. In a certain proportion also of these cases there are indications of increased blood-pressure and actual, rather than relative, strain upon the cusps. Thus it is this secondary strain that is responsible for the diffuse and generalized mitral thickening seen in these cases, rather than the primary irritant—the cause of acute rheumatism.

We have here another example to add to the abundant instances of the existence of "Vicious Circles" recently accumulated by Dr. J. B. Hurry.* Whether from extrinsic or intrinsic causes, the cusps become subjected to strain, and reacting, there is tissue growth with thickening and fibrosis. This very thickening makes them function less perfectly, and as a result they are subjected to more strain. More strain leads to further fibrosis—and so progressively there are developed those conditions of extreme diffuse thickening, contraction, deformity and degeneration of the heart-valves, with which we are so familiar. Here, indeed, Ossa is piled on Pelion, for the incompetency of the fibrosed valves leads to hypertrophy of the ventricular muscle in order that the circulation may be preserved. This hypertrophy results in more powerful contraction, with resultant heightened intracardiac pressure. The forces thus acting upon the damaged valves and inducing strain are not constant, but exhibit progressive augmentation. There is no "let up" to the process until the strain on the heart walls gives place to overstrain and cardiac failure is the result.

*Vicious Circles in Disease. J. and A. Churchill, London, 1911.

DISPLACEMENTS OF THE HEART AND DIAPHRAGM TO-
GETHER WITH DISTURBANCES IN THE FUNCTION OF
THE LATTER AS CAUSES OF SYMPTOMS
IN PULMONARY TUBERCULOSIS.

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Much has been written regarding the various organic heart lesions in their relation to tuberculosis; the subject of the relatively small heart has been thoroughly discussed; the question of toxic degeneration of the heart-muscle has received some consideration; but there are certain other conditions referable to the circulatory system in tuberculosis, which, though usually present, have received scant attention heretofore. I refer to the various displacements of the heart and the displacements and altered function of the diaphragm.

It is somewhat surprising that these conditions have not received more attention from clinicians when we consider the fact that they are present and produce symptoms in nearly all patients who are suffering from tuberculosis. There are displacements of the heart in some form and to some degree in all cases where either a lessening or increase in the volume of the lungs occurs. The function of the diaphragm is interfered with from the very beginning of tuberculosis. It is displaced either upwards or downwards in nearly all patients who go on to an advanced stage of the disease, the dislocation depending upon the inter-relationship between the intra-abdominal and intrathoracic pressures.

The symptoms which result from these conditions can only be understood in connection with the physiology of the heart and diaphragm. The heart is normally placed in the thoracic cavity in a position which enables it to perform its function with ease. The circulation of the blood is aided by every normal respiration. Any condition which changes the position of the heart, putting it in a position less favorable to action, and any condition which interferes with full and free respiratory movements, therefore interferes with the circulation of the blood. The diaphragm is considered the chief muscle of respiration. It is also an important aid to circulation. It is aided in its action by the abdominal muscles.

The normal contraction of the diaphragm acts by forcing the abdominal viscera downwards and forwards, increasing the anteroposterior and lateral diameters of the abdomen and lower thoracic cavity, and at the same time increasing the thoracic space and decreasing the abdominal space from above downwards, thus reducing the abdominal space and increas-

ing the thoracic space as a whole. It can be seen that the abdominal muscles must play an important part in this action. Their tension is increased by the contraction of the diaphragm, and we assume that their recoil is a part in the expiratory act; in fact, it seems probable that this recoil is not wholly passive.

This increased space in the thoracic cavity allows an inrush of air into the lungs and at the same time dilates the heart and favors the return flow of blood from the large veins into the right auricle. This pump-like action upon the large veins is the greater the freer the respiratory action. Not only is there an increased suction action favoring the return flow through the *venæ cavæ*, but, in the abdomen, there is a positive force exerted by the contracting diaphragm pressing upon the abdominal viscera and squeezing the blood out of them and forcing it into the larger veins and favoring its flow on to the heart. The natural result of the conditions which I am considering, then, is to make the work of the heart more difficult and to cause an accumulation of blood in the abdominal viscera. We will discuss the more definite results as we proceed.

The heart and the diaphragm are so closely associated that we can hardly conceive of a displacement of one without the displacement of the other, except within certain narrow limitations afforded by a pericardium sufficiently large to permit the heart to move from side to side, as the body assumes different positions.

The symptoms and end results produced by the displacements of the heart and the disturbances in the function of the diaphragm are different. The ultimate effect of the displacement of the heart *per se* is more serious than that of displacement of the diaphragm, although a displacement of the diaphragm probably produces the greater number of symptoms, most of which are of a cardioneurotic nature.

The displacement of the heart also causes many cardioneurotic symptoms, but what is more serious, it leads to organic changes.

The effect resulting from destruction of tissue and contraction of the upper lobe of the left lung is to draw the heart upwards and to the left. Not only is the heart thrown out of its normal position and forced to work at a disadvantage because of this, but the probabilities are that the outlines of the pericardium are changed so that the pericardial space is somewhat reduced. The altered position causes the heart to drag on the large vessels, produces a decrease in the curve of the arch of the aorta, thus bringing about a condition which interferes with the free flow of blood into the systemic arteries. The same dragging effect is exerted on the other vessels pulling the large veins out of their normal course and interfering with the return flow of blood to the right heart.

If the destruction of tissue and contraction occurs in the upper lobe of the right lung, the heart is drawn upward and to the right. The curve in the arch of the aorta is increased and pouching is favored. The heart

is again thrown out of its normal position and the *venæ cavæ* and other intrathoracic vessels are drawn from their regular course; and, again, obstacles to filling and emptying the heart are encountered.

If the heart hangs low in the chest it increases the distance from the apex to the large vessels, and thus the heart drags upon them, producing disturbances in its function.

If the heart is displaced directly upwards, the result is a shortening of the distance between the apex and the large vessels which tend to produce a pouching of the aorta. This is apt to occur when both apices are the seat of destructive change followed by contraction; this, however, rarely occurs.

In order to overcome the extra pressure in the circulation in the pulmonary system, the right heart has already hypertrophied and now the left ventricle is compelled to hypertrophy in order to overcome the extra burden thrown upon it by the heart's displacement and the changes in the aorta and general arterial system. In this connection I would like to call attention to the changes which occur throughout the arterial system as a result of the toxins in tuberculosis. In a former paper¹ I reported the results of examination of one hundred and sixty-two tuberculous patients. Of these, the arteries were palpable in ninety-four instances. Of ninety-three of these who gave a history of illness lasting more than two years, the radials were palpable in sixty instances. From my study I drew the conclusions that a thickening of the arteries takes place in chronic tuberculosis as a result of the prolonged action of the toxins. Since writing this paper I have made further observations which fully substantiate the results there reported. A short time ago a young girl came under my care who had been suffering from pulmonary tuberculosis for two years. The disease had not taken a very active form, although percussion dulness and physical signs extended to the third rib on the right. Although she was only eleven years old, her radials were distinctly palpable. When we consider the changes which I have mentioned in the aorta, the thickening of the peripheral arteries, the displacements of the heart which cause it to work at a disadvantage, and the fact that the heart-muscle early undergoes pathological change, we can see that the end result must of necessity be degeneration.

The cause of death in nearly all tuberculous patients is of cardiac origin. It can be seen that these dislocations interfere with the easy working of the heart and throw extra burdens upon it, all of which have a tendency to cripple its working ability and cause degeneration.

The immediate symptoms produced by displacements of the heart are those of cardiac embarrassment. I have had the opportunity of studying several hearts where the displacement occurred quickly, owing to the rapid destruction of tissue in the neighborhood of its borders. In one case the heart moved more than one inch to the right within a few days' time, owing to the formation of a large cavity in the right lung near

the heart border. In all cases which I have watched, the symptoms were those of extreme weakness, shortness of breath, rapid heart action and tendency to syncope, loss of appetite and nausea, especially if the patient changed his position. Where the heart moves more slowly the symptoms, of course, are not so marked. The main ones of which the patient complains are those of rapid heart action and shortness of breath upon exertion.

The symptoms produced by high and low position of the diaphragm have been carefully described by Wenckebach.² Arterial anemia and venous congestion, especially in the splanchnic area, are quite pronounced. These patients appear pale, although if the blood is examined there is little or no anemia present. This is one of the particular characteristics of the tuberculous patient, and I do not doubt that these anemic appearances, in many instances, are due to this arterial anemia produced by the altered function of the diaphragm. The pulse is small and usually rapid, the patients suffer from shortness of breath and a general lack of nutrition. They often suffer from palpitation and feel faint. Their extremities are often cold. This disturbed function of the diaphragm is unquestionably another factor in the low blood-pressure of the tuberculous patient. Disturbance of function, on the part of the abdominal viscera, such as altered gastric secretion, constipation, diarrhea, colitis and flatulence are very common. One thing which I have noted regarding these abdominal conditions is that they not only seem to be much more frequent in the class of patients which I am now describing than in other individuals, but they also seem to be more serious and more difficult to relieve. I consider this due partly to the chronic venous congestion resulting from the altered position of the diaphragm.

Another feature which is present in most cases is an unstable condition on the part of the nervous system. While there is always some neurasthenia present in patients suffering from tuberculosis because of the toxins liberated by the tubercle bacilli, yet in these cases of severe disturbance, on the part of the diaphragm, there is a neurasthenia which is more pronounced and more difficult to relieve than that found in the tuberculous patient where these conditions are absent or present to a lesser degree.

The hypotension found in those suffering from pulmonary tuberculosis is probably a result of several factors. The fact that it has been noted to a slight extent in early cases has been used as an argument in favor of the toxine theory of its origin. It must be recalled, however, that the interferences in the function of the diaphragm also appear early in tuberculosis and favor hypotension by interfering with the return flow of blood to the heart, thereby producing a venous congestion and a relative arterial anemia. In some instances, this action is scarcely felt in the early stage of the disease. In others it is more pronounced. As the disease advances, however, the disturbance in the function of the diaphragm becomes

greater, and changes in the position of the heart, as well as in the muscle itself, take place, all of which favor hypotension. While the toxins are probably the greater factor in the production of hypotension in incipient tuberculosis, in the advanced stages of the disease they must take a place secondary to the mechanical causes which manifest themselves on the part of the circulatory system. The pulse in advanced tuberculosis, where the heart is fully competent, is not far from normal in its rate as long as the patient remains at rest, or even under light exercise; but, if more strenuous exercise is engaged in, then the heart shows signs of being overworked. The pulse increases to a greater rate than would be normal for the amount of work done, and fails to return to the normal limits within a time which would be considered normal for a healthy heart.

There is also another large class of tuberculous patients whose hearts are fully competent so long as they remain at rest; but, who, as soon as they undertake exercise, suffer from heart embarrassment, the pulse becoming rapid, dyspnea appearing, the patient feeling weak, and sometimes, in severe cases, dizzy and faint. As long as the patient is at rest the functions of the body are carried on economically, the minimum amount of oxygen is required to produce satisfactory aëration of the blood; but, when exertion is attempted, a greater amount of oxygenated blood is called for than the heart can supply. The heart can no longer measure up to the increased work that is thrown upon it. It has been estimated that the flow of blood is four or five times as rapid in active muscle as in resting muscle; that rising to a position ready for walking from the resting position doubles the amount of oxygen required by the tissues; and that starting to walk quadruples it. The heart, in its weakened condition, working under the disadvantage of displacement, together with the changes in the arteries and the relatively large amount of blood in the veins, causing a relatively small amount of blood to be discharged at each systole, is unable to meet these circulatory requirements.

It can thus be seen that, if the functions of the body are to be carried on normally, the circulatory system must not be seriously interfered with, the blood must be forced through the lungs in sufficient volume and with sufficient rapidity to provide the oxygen required to carry them on. In advanced tuberculosis, however, we have conditions which are especially difficult to overcome. Besides the reduction in the capacity of the lungs themselves, we have conditions on the part of the heart and circulatory system which make it extremely difficult for the circulation to be maintained in a manner capable of providing the oxygen which is required by any extra amount of exertion; hence the symptoms of cardiac embarrassment so frequently found.

It is necessary now to discuss more clearly the causes of these conditions. The displacement of the heart and diaphragm is due to loss of tissue and the resulting compensations on the part of other tissues. The

disturbance in function of the diaphragm, however, is probably of reflex origin.

The lessened motion of the diaphragm on the affected side was pointed out by Williams,³ as being an early sign of tuberculosis. He determined the phenomenon by use of the *x*-ray. Its explanation has not been wholly clear. De la Camp has suggested that it is due to the phrenic nerves being bound down in pleural adhesions at the pulmonary apex. Hofbauer and Holzkecht have suggested that it is caused by a decreased

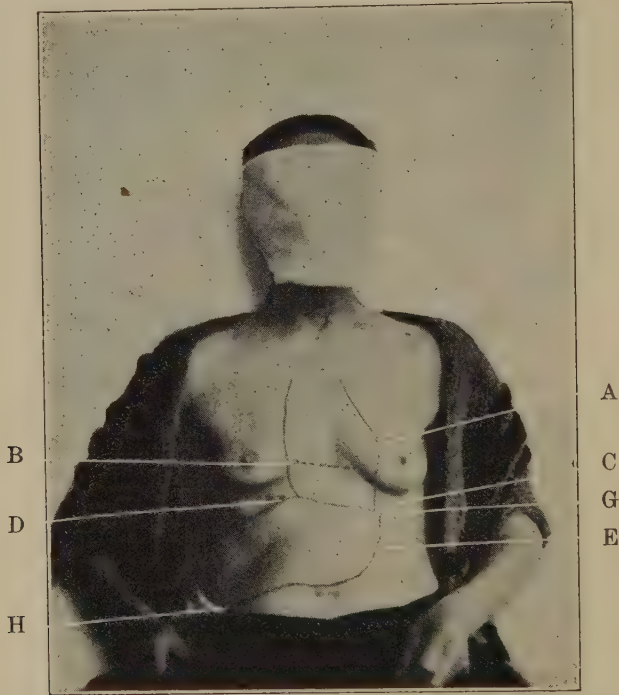


Fig. 1.—Showing the low position of the diaphragm, heart and liver. The broken line BA marks the xipho-sternal angle, which is normally in such shaped chests as this, on a line with the lower borders of the heart. DE represents the lower border of the heart; BDCE, the diaphragm and GH, the lower border of the liver. This picture was taken after patient had been treated by adhesive straps and had gained about fifteen pounds in weight. Thus the liver is higher than mentioned in the text.

elasticity in that portion of the lung which is involved and by a relaxation of the remaining tissue, thus causing a general lessening of the contractile power of the lung as a whole. My recent studies convince me that the phenomenon is of reflex origin. The phrenic nerve is given off from the third and fourth or fourth and fifth cervical roots. This is the portion of the cord, which receives the impulses from the lungs through the sympathetic nerves; and the limited motion of the diaphragm is

accounted for in the same manner as the contraction of the neck and chest muscles, as described by Pottenger,⁴ viz., a reflex stimulation, the impulse traveling from the inflamed lung through the sympathetic nerves to the cord, there stimulating the adjacent cells in the same segment of the cord, and causing impulses to be sent out through the fibres of the motor nerve or nerves arising in the same segment, to the muscles, which cause them to assume a state of tonic contraction. With this explanation it can be seen that the function of the diaphragm is interfered with early in tuberculosis, and that the interference must keep up throughout the disease.*

We recognize other factors in tuberculosis which interfere with the normal action of the diaphragm. Among the most common are emphysema, pleural effusions and adhesions, contraction of the lungs and displacement of the heart and mediastinum above the diaphragm and loss or increase of tissue and flatulence below the diaphragm; but, while these are sometimes present, the effect of the reflex stimulation through the phrenic nerves is always present. The diaphragm assumes a high or low position according to whether the pulmonary space decreases or increases. When a severe destructive process develops in one or both lobes, as it often does in the upper lobes, and this is followed by marked contraction, the diaphragm is apt to assume a higher position than normal. Where, on the other hand, the disease develops slowly, and through continuous coughing extending probably over years, an emphysema develops, we find the diaphragm low, and a condition of general visceroptosis present.

The abnormal positions of the heart and diaphragm can be studied by the use of the *x*-rays, although the ordinary methods of physical examination, when carefully applied, are sufficient for detecting them. In our teachings upon the location of the heart within the thoracic cavity we have probably failed to make it clear that there is a natural variation in the position of the heart depending upon the shape of the thorax. We must not expect the apex, base and lateral borders to occupy the same relative positions, with reference to the surface landmarks, in a very narrow, long chest, as in a short, wide chest. This is important in studying the conditions before us. If we accept the rule that a line drawn from the articulation of the xiphoid appendix to the tip of the eighth thoracic spine should touch the dome of the diaphragm and thus be on a level with the under surface of the heart, we will find many exceptions to it in the long chests of tuberculous patients, even when examined before changes have occurred which cause the heart to assume a lower position. Hirschfelder⁵ considers this pathological, and suggests a line of treatment for its correction; but I cannot believe that it should be considered so. It seems to me normal for that type of chest, and as long as the diaphragm is functioning normally and in the natural

*These problems have been discussed quite thoroughly elsewhere and will soon be published in Brauer's *Beiträge zur Tuberkulose*.

relationship with the organs lying above and below it, it seems but natural to consider the condition as normal. When the heart hangs low, the horizontal diameter is decreased because the apex has dropped and the transverse diameter represents a section more nearly perpendicular to the long axis of the heart than that where the heart is in its normal position. The superior dulness of the heart is also lower than normal, being often below the third rib. When very low the right ventricle may be seen to pulsate in the epigastrium.

The following is the most extreme case of low diaphragm and general visceroptosis that I have detected among my tuberculous patients. Figure (1) shows a photograph of the outlines of the organs as made by me. Mrs. L., aged fifty-eight. Always a hard worker. Had hemorrhage ten years ago and had coughed during the winters ever since. For the past two years had never been free from cough. Expectoration contains bacilli. Has had more or less stomach trouble for the last ten years. About two years ago began having pains in the epigastrium and showed signs of loss of endurance and sensations of weakness with rapid pulse and some dyspnea on exertion. *Physical examination.*—Tuberculous infiltration in upper portion of both lungs, remaining portions emphysematous. Lower margin of lungs reaching inferior margin of throat; the eighth rib in mid-clavicular line and twelfth vertebra posteriorly. The abdominal organs were all low, the right kidney was in the right anterior lumbar region. The liver had fallen away from the under surface of the diaphragm and scarcely moved on inspiration. Its lower border was one inch below the umbilicus. The lower portion of the thorax sank in at each inspiration showing the *typus paradoxus*. The pulsation of the heart was plainly visible in the epigastrium; the apex beat was under the seventh rib slightly nearer the sternum than normal; the point of maximum intensity for the pulmonary and aortic valves was in the third interspace. Pulsus paradoxus was present. Aside from the chronic cough and emphysema this patient had very flabby abdominal muscles, which also favored this general visceroptosis. This is characteristic of the type of chronic coughers with emphysema which I have described above; although the degree of ptosis is extreme.

When the heart is displaced upwards, its transverse diameter is increased. This is especially true when the displacement is toward the left. If the apex beat can be found, it is an important aid; but very often in advanced tuberculosis it cannot be detected. I would like to call attention, especially, to the fact that the point of maximum impulse is not always the apex; for often the impulse is due to the enlarged right ventricle, the left ventricle having been pushed backwards away from the chest wall. As an example of high positions of the diaphragm and upward displacement of the heart, I would like to cite the following case:—Miss S., aged twenty-two. Ill three years of pulmonary tuberculosis, now in state of arrest. Upper lobe of left lung seat of cavity

formation and marked contraction, the lower borders of the lung being drawn up to the fifth rib in the mammary line. Right lung shows compensatory emphysema extending beyond the medium line to the left. The diaphragm on the left is high. The heart is drawn to the left, the apex being in the fourth interspace to the left of the nipple line, the right border at the right border of the sternum. The base of the heart is also pushed upwards and to the left. The patient shows arterial anemia, being pale. Has very little endurance, rapid heart, dyspnea on exertion, cold extremities, at times feels dizzy and on several occasions has almost fainted.

The important thing to know is that these conditions produce symptoms which are often very annoying. They are often thought to be indicative of serious heart lesions. Fortunately, they can be relieved to a large degree, if recognized, by the application of suitable abdominal binders. Not only are the cardioneurotic symptoms, just mentioned, relieved by proper abdominal support, but oftentimes intractable symptoms on the part of the gastro-intestinal tract, such as indigestion, constipation, diarrhea, colitis and flatulence are relieved only after the organs are held up by proper binder. When we realize the importance of good heart action, a stable nervous system and good digestion in tuberculosis, the importance of looking for and correcting these conditions can be appreciated.

The symptoms arising from the various displacements of the heart are not so readily relieved, for the heart cannot be replaced except in those instances where it is displaced downwards. The organ, when once displaced, is compelled to continue its work at a disadvantage. In those instances, however, where the change is slight, the symptoms are negligible. Where it is greater the symptoms are more marked; but the most that we, as physicians, can do is to shield the heart as much as possible from overstrain.

Heart and diaphragm displacement and alteration in the function of the diaphragm are found to some degree as previously mentioned, in practically all patients suffering from tuberculosis. Of course, the disturbances are greater in the advanced cases. Physicians who are treating advanced cases should be on the watch for the symptoms referable to these conditions, and should not allow themselves to be deceived into thinking them an indication of the more serious heart lesions. A correct understanding of them will be of untold value to the patient, and will relieve the physician of much unnecessary anxiety.

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THE USE OF RÖNTGEN RAYS FOR EXAMINING THE HEART.

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If, at the kind request of the editor, I here endeavor to describe what services can be rendered by Röntgen rays when examining the heart, it can of course only be in the briefest outline without any claim to completeness. Especially as to the technical details which I cannot discuss fully here, I shall have to content myself with referring, when necessary, to the literature bearing upon the subject.

Generally speaking, x -rays are used for the following purposes when examining the heart:—

1. Observing the action of the heart.
2. Determining the position of the heart.
3. Ascertaining the form of the heart.
4. Defining the size of the heart.

However, to decide whether, in any individual case, there has been any pathological change in one of these four points is only possible, when we have an exact knowledge of the normal condition of the Röntgen shadow. In the following, therefore, I will give a description of the normal condition before proceeding to the pathological state.

The action of the heart is observed by means of the screen. If we choose the sagittal direction of the rays—passing through the body from back to front (dorsoventral), or vice versa (ventrodorsal), we see the dark medium shadow bounded on the right and left by the light shadow of the lungs, pulsating gently in the two lower thirds. The character of these movements shows slight variations in different places on the margin, which make it possible to draw conclusions as to the section which produces the movements.

The so-called "medium shadow" is formed by different organs casting Röntgen shadows. Besides the spinal column and the sternum, this is done chiefly by the heart and the great vessels. In a normal condition the shadow of the heart and the large vessels overlaps the other parts everywhere, both to the right and to the left, being clearly outlined in curves against the light shadow of the lungs. To the right we see two curves, the right lower one, the curve of the auricle, and the right upper one, the curve of the large vessels. To the left we see four curves, the left lower one, the curve of the left ventricle, adjoining that of the left

auricle (in normal conditions formed only by the appendix of the left auricle), then farther up the curve of the pulmonary artery, and last of all the curve of the aorta. The exact definition of these curved outlines has given rise to many controversial papers which, however, it will be impossible for me to discuss here. In the clearing up of this question studies on the corpse and above all the observing of the pulsation have shown the following results:—

The right lower curve evinces but a slight and gentle pulsation and is presystolic compared with the apex-beat. The right upper curve, in the extremely rare cases when the veins form the outline, does not show any pulsation at all, whereas in most cases, the aorta forming the outlines, a slight pulsation may be detected alternating with that of the lower curve. On the left side we see a kind of undulating movement, which we can best describe as vermiform. The contraction of the lower left curve corresponds, as is shown by palpation, with the apex-beat. On the curve of the aorta we see a stronger pulsation, a somewhat slighter one on the curve of the pulmonary artery. If the curve of the left auricle is distinctly marked, we see its contractions preceding those of the left lower curve of the ventricle. The movements of the auricle are rapid and convulsive, those of the left ventricle pumping and more copious, those of the vessels slight and sluggish. We can, moreover, generally distinguish both a feeble and a stronger type of action.

In this latter point it is not always easy to draw a line pathologically. In cases of chlorosis, chronic tuberculosis, etc., we often find an abnormally feeble type of action; with nervous people, especially those suffering from neurasthenia, a decidedly more vigorous type of action. The same vigorous form of pulsation is likewise discernible in cases of aortic insufficiency, bradycardia and heart-block; an abnormally feeble pulsation in cases of myocarditis. With tachycardia paroxysmalis we have the impression of a vibrating, more or less irregular movement, whilst with the Basedow-patients there is a more vigorous pulsation of the heart, notwithstanding an increased rapidity of movement.

Variations in the marginal curves from the normal type of pulsation occur with different diseases of the heart; for example, very vigorous pulsatory movements of the curve of the pulmonary artery in cases of persistent ductus Botalli. The same thing is to be seen in the rare cases of perforation of an aneurysm in the pulmonary artery, as well as with congestion in the lungs. If the intraventricular septum is deficient, we can see ventricular movements of the right lower curve. In affections of the mitral valves, especially in mitral stenosis, a violent pulsation of the auricle is usually to be observed. In cases of tricuspid incompetence there is a pulsatory movement of the superior vena cava, which then forms the outline. F. Kraus and Hofmann-Duesseldorf have, moreover, shown that roentgenoscopy can also be employed for examining the reference of the pulse, to the cardiac action; for example, to decide.

whether an intermission of the pulse corresponds with an intermission of the heart. The question whether the patient is suffering from heart-block or only bradycardia can also be easily decided on the Röntgen screen. In case of "dissociation" I was able to observe that one pulsation of the aorta always corresponded with 2-3 pulsations of the right auricle.

To make roentgenoscopic observations of the pulsations of the heart, a considerable amount of practice and experience is requisite. We have, however, lately succeeded in reflecting and studying the pulsation of the heart by means of roentgencinematography. The first pictures of this kind I was able to demonstrate before the "Verein fuer innere Medizin" in Berlin in the year 1909. Meantime I have constructed better cinematographic apparatus, so that the change of plates takes place more accurately. By employing better screens (the Sinegran screen)* and a one-flash apparatus (Unipuls)* the pictures have become much more distinct. Quite recently I have combined the roentgencinematograph with an electrocardiograph, so that now for every picture the respective phase of the heart can be exactly defined. I must also mention here the recent attempts to represent on the screen the circulation of the blood in the large vessels and in the heart. Alwens and Frank have succeeded in doing this with animals by injecting bismuth-oil in the blood-vessels. Whether these experiments will and can afterwards be extended to human beings or not, is of course very questionable.

Whereas for studying the pulsation of the heart we chiefly employ the sagittal diameter, it is found better to make use also of the frontal diameter at the same time, when examining *the position of the heart*. I must here refrain from discussing the pictures made by the oblique diameter, as they can scarcely be described without illustration. The oblique diameter is of especial importance for examining the aorta, which, however, is outside the subject of this article, and to decide whether a bulging out of the left side of the heart is caused by the auricle or the pulmonary artery. In general the simple method of fluoroscopy will be found sufficient, but more exact results are obtained by employing one of the orthoröntgenographic methods, especially orthodiagraphy. A roentgenphotograph is rarely necessary to be taken, unless it be to secure an illustration of a rare case, or to find out the cause of a dislocation by means of photography.

Examination by means of x-rays has above all placed the fact beyond doubt that there is no invariable rule for the position of the heart. It has been ascertained orthodiagraphically that about one-third of the heart lies to the right and two-thirds to the left of the median line. According as the position of the longidiameter of the orthodiagram (it corresponds approximately to the axis of the heart) is to the axis of the body, we speak of the perpendicular, oblique, or horizontal position of the heart. By far the most frequent position is slightly oblique. The

*Reiniger, Gebbert and Schall, Berlin.

perpendicular position is found chiefly with young, slender people, but also in cases of the so-called *habitus asthenicus* of adults, whereas the horizontal position is generally speaking a peculiarity of old age. Again, space will not allow me to give exact topographical details. I will only mention the very important fact, that the apex-beat is mostly felt outside the cardiac dulness, which we find by means of orthodiagraphy, the reason being that the apex-beat is directed obliquely towards the wall of the thorax.

Our knowledge of the position of the heart is greatly increased by employing the frontal diameter. We see that the heart is placed obliquely in the thorax, at the top backwards and at the bottom forwards, and is fixed firmly between the wall of the thorax and the diaphragm. Therefore we speak of the part of the heart which is sunk into the shadow of the diaphragm. Another result of these positions is the division of the frontal shadow of the thorax into the front retrosternal and a rear retrocardial region of the lungs, between which, as described above, the shadow of the heart is placed diagonally.

Of the physiological facts that influence the position of the heart, the respiration must be mentioned first. By the pericardium, the heart is held fast partly to the diaphragm (the *Herzboden*) and must therefore take part in all the movements of the latter. During inspiration it becomes longer, narrower, and more perpendicular; during expiration broader, shorter, and more horizontal. By means of roentgencinematographic studies I have been able to ascertain that, with normal gentle respiration, no change in the size of the heart takes place, there being merely the above-mentioned dislocation.

When the position of the body is changed, the position of the heart passes through changes similar to those caused by respiration. When lying on the left side, the heart moves on an average of 2.5 cm.; when lying on the right side on an average of 1.5 cm. But this degree of movement is also dependent upon various other circumstances, *e. g.*, corpulency, etc. When lying in a horizontal position the heart moves upward and becomes broader than when standing or sitting and also seems to be larger. It is for this reason that Moritz has declared the inadvisability of measuring the heart when the body is in a vertical position, but the arguments which he has brought forward have, on closer examination, proved altogether untenable, as I have shown in a paper on this subject in the *Annalen der städt. Krankenhäuser in Muenchen* (Vol. XIII).

Among the pathological variations of the normal position of the heart, we may first mention the congenital dislocation of the heart, the most frequent of which is the complete lateral inversion in cases of *situs viscerum inversus*. It is only since *x*-rays have been used for examining the heart, that we know that this is of relatively frequent occurrence. I have myself reported two cases in the *Atlas und Grundriss. Rönt-*

gendiagnostik in der inneren Medizin (J. F. Lehmann, Munich, 1909).

Acquired dislocations of the heart are also of very frequent occurrence. Every abnormal position of the diaphragm can lead to such a dislocation. If the left diaphragm is raised by an abnormal quantity of gas in the stomach, the heart is moved to the right; on the other hand, when the right diaphragm is raised by an enlargement of the liver, the heart is moved to the left. A similar effect is produced by tumors in the abdomen, ascites, pregnancy, etc. To this group may also be added the "drop-heart" (medium position of the heart) in cases of *habitus phthisicus*. Just in the same manner as the heart changes its position following the movements of the supporting diaphragm, so it also follows the change that takes place in the lungs. Tumors and pleuritic exudations in the lungs press the heart to one side, pleuritic adhesions draw it aside, emphysema of one side of the lungs thrusts it to the other side, especially when in the latter, through pathological processes, the quantity of air is reduced. Thus in tuberculosis of the lungs we find a manifold variety of positions. Finally the suspending apparatus of the heart, that is the large vessel, changes its position by becoming longer, and sinking. The heart then takes the horizontal position (old age heart). I may also mention here the emphysema-heart: with emphysema of the lungs the diaphragm is flattened, the "Herzboden" being therefore low down; and the result is that the heart is very much narrowed and stretched.

The motility of the heart also shows variations from the normal under pathological conditions. Thus every change in the normal type of respiration produces a corresponding change in the respiratory movements of the heart. Especially well known is the "inspiratory" dislocation of the mediastinum into that half of the thorax where the stenosis is situated, in all processes that are combined with the contraction or compression of a lung, as for example stenosis of one bronchia, pneumothorax, aneurysm, etc. Adhesions between pleura and pericardium, even when they are very slight, often become only manifest by abnormal respiratory movements of the heart. Another very appropriate means of finding out the changed motility of the heart is examination in different positions of the body. We find the motility of the heart reduced in all above-mentioned cases of dislocation or abnormal respiratory movements, when lying on the side, and an increased motility in cases of aggravated chlorosis, enteroptotic habitus, etc.

As regards the normal *form of the heart*, something was said, when discussing the marginal curves in the shadow of the heart and the large vessels. The entire sagittal silhouette of the heart appears to us in a somewhat elongated egg-form, but it is not possible to give any definition that can be generally applied. Every heart shows slight variations, so that there are never two heart-orthodiagrams of different persons which are exactly alike. Nevertheless, it is comparatively easy to detect a change in the shadow of the heart, as we usually find, besides general changes

in form and position, extremely typical changes in the different marginal curves, and these are as a rule combined with a changed type of pulsation. It is, I think, not saying too much, when I assert that just this branch of the Röntgen diagnosis of the heart will in future bear most fruit. We find occasionally this subject mentioned by Santiard, Grunmach, Köhler, Destot, de la Camp, Holzknecht and F. Kräus. The first attempt, however, to fix a typical form of the heart for most of the cardiac affections was made by Th. Grædel and myself, the results of which were on the whole confirmed by Köhler and Dietlen. For the congenital heart diseases we have lately composed a röntgenological symptomatology in the *Deutsches Archiv fuer Klinische Medizin*.

I will give here a short sketch of the best known pathological forms of the heart, without, of course, giving anatomical explanations; details on this subject will be found in the above-mentioned Atlas, p. 151-156, and in another work of mine that is in print "Die Röntgendiagnostik der Herz-und Gefässkrankungen" (Hermann Meusser, Berlin, 1911).

In all cases of an affected aortic valve we find a so-called "aortic heart." It is pronouncedly horizontal, "recumbent egg-form." The greatest increase in size is always to be found in the left lower curve, a less pronounced one on the right lower curve. The greatest enlargement of the heart we find in cases of aortic insufficiency, when we can almost always see a pulsatory, already anatomically fixed dilatation of the aorta in the form of a bulging-out of the right upper curve. Stenosis of the aorta shows similar symptoms—of course without dilatation of the aorta—but in a less degree. The same thing may be said of the sclerotic stenosis of the aorta, sclerosis in the beginning of the aorta, aortic aneurysm near the heart, and all other cases (*e. g.*, old age heart) in which the evacuation of the left ventricle is impeded.

A comparatively small heart is found in cases of mitral stenosis, which is but seldom without complications. Frequently, even the curve of the left ventricle is reduced, which sometimes denotes a hypoplasia of the left ventricle. The other marginal curves have generally nothing particular to show, except the curve of the left auricle, which is enormously enlarged and pulsates violently. Thus we have an "upright oval form."

Another picture is afforded by insufficiency of the mitral valve. Slight cases may occur without the form being changed in the least. A mitral insufficiency of longer standing, and especially if it has been frequently decompensated always results in a "ball-formed" (round) heart. The heart is enlarged equally on all sides. The curve of the right auricle is usually very much bulged out; the curve of the left ventricle is enlarged and at the top melts into the curve of the right ventricle, which bulges out to the left, upwards towards the arm-pit, and thus thrusts back the curve of the left auricle and at the same time covers the left auricle itself, which is of course greatly dilated.

At the same time I must state here, that pure insufficiency of the mitral

valve, as well as the pure mitral stenosis, is of rather rare occurrence. The two affections of the valves occur much more frequently combined than we can clinically state it; therefore, we very often find the characteristics of the two forms united. The curve of the pulmonary artery can be enlarged by all affections of the mitral valve, mostly in case of decompensation. In such cases we can frequently distinguish as a special curve, in the curve of the right auricle, the appendix of the right auricle.

It is also worthy of mention that with combined lesions of the mitral and aortic valves, all the peculiarities of the different defects of these valves are discernible. In such cases the marked oblique position of the heart is typical. In cases of tricuspid insufficiency we often see enormous changes in the size of the right auricle.

Of all the congenital affections, the persistence of the ductus arteriosus Botalli affords the most typical Röntgen picture. The most evident symptoms are the distension and pulsation of the pulmonary artery, and the enlargement of the right ventricle, by which a round heart (mitral heart) is formed.

Congenital stenosis of the aorta (I have myself observed two cases) also shows an enlargement of the curve of the pulmonary artery. In this affection the left ventricle is as a rule enlarged, so that the heart assumes a recumbent cylindrical or egg-form (aortic heart). In cases of stenosis of the pulmonary artery I have not been able to detect any changes whatever in the Röntgen picture.

Ventricular movements in the right margin of the shadow of the heart signify a defect in the ventricular septum. On the other hand, in cases of foramen ovale apertum we have likewise found no special roentgenological symptom.

For the different forms of myocarditis, cardiac complaints connected with chronic nephritis or arteriosclerosis, neurosis of the heart, phrenocardia, constitutional weakness of the heart, etc., many diagnostic Röntgen symptoms can be enumerated; however, as this would lead me too far, I refer for further information to my above-mentioned works.

An exact description of the Röntgen shadow in cases of pericarditis also surpasses the limits of this paper. In cases of exudative pericarditis we see the well-known triangular form of the heart shadow. A good Röntgen photograph is of especially great service when the exudation has to be removed by operation.

In cases of dry pericarditis and residues of an exudative pericarditis, the pericardiac adhesions can very easily be demonstrated. This too is necessary in case of operations, if the working of the heart is to be relieved by "cardiolysis." Calcinations of the heart have not yet been demonstrated *intra vitam*. A short time ago I found, for the first time, a shadow of calcination in the pericardium. The case in question, published in *Fortschritte auf dem Gebiet der Röntgenstrahlen*, Vol. XVI., is peculiarly interesting because it was at the same time possible to recognize the separate cavities of the heart.

Before passing on to the results of *defining the size of the heart*, I must give a brief explanation of the orthoröntgenographical methods, referring for all further details to my instructions for working with parallel x -rays ("Die Orthoröntgenographie," J. F. Lehmann, Munich).

Of the different photographic methods only the "Kœhler teloröntgenography" has proved a success. The reason for this is, that with 2 m. distance between the tube and the plate only extremely small changes in size take place, and these are so small that they can be disregarded without any detriment. It is true that this method is technically easier to use, since we generally employ short exposures. But the cost of production compared with orthodiagraphy is disproportionately high.

Orthodiagraphy will in all probability continue in use in future where examinations of the heart by x -rays are carried on regularly. The great advantage of orthodiagraphy is the employment of only one x -ray (that is to say, one small sheaf of rays) which is carried round the heart, thus showing the outlines of the heart. The first apparatus, which, however, could only be used for horizontal drawings, was that of Moritz. For perpendicular examinations that of Levy-Dorn is a very practical construction. This I succeeded in modifying considerably some years ago. Perpendicular orthodiagraphy, being much more practical than horizontal, has now come into general use. If examinations are always made in a sitting posture, as I have proposed, the results are in every respect indisputable.

The special value of the orthodiagram is to be found in the exact reproduction of the form of the heart and its details; the measurements seem to me to be only of secondary importance. For, in spite of all its exactness, the orthodiagram gives us only approximate and not absolute figures. I do not mean by this that exact measurements of the heart are not necessary, and for which orthodiagraphy still remains indisputably the safest and best method.

For the measuring of the orthodiagram, numerous instructions have been given. For general practice, however, it is sufficient to keep to the few sizes that can be really measured with accuracy. These are the greatest distance between the right and left margins of the heart and the middle side of the sternum, the median distance to the right and to the left, which together give the transverse dimension; and the longidiameter, the greatest distance of the heart apex from the point of the division between the two right curves. By the examination of a large number of persons with healthy hearts for these dimensions, a list of average figures has been drawn up. This was done for horizontal diagraphy by Dietlen, for perpendicular orthodiagrams (sitting) by myself, and for children's hearts by Veith. In this way we are now enabled to detect even relatively slight deviations of the heart measurements from normal conditions. But even at the present day we are not able, and this should be especially emphasized, to measure the size of the heart to a millimeter. For just

the numerous examinations of healthy hearts have shown that even, when we take into consideration the size of the body, the weight of the body, and the age of the individual, there are still great variations in the average figures. The profession, the condition of nourishment and many other factors have also to be taken in account.

Besides determining physiological changes in the heart and its use in defining exactly the enlargement of the heart, orthodiagraphy has rendered very good service in a number of more or less experimental works, especially as to variations in the volume of the heart; and it is used daily for this purpose. I can only give here a summary of the most important of these applications and their results.

Bingel found that fencing had no influence on the size of the heart. The same thing was ascertained by Lennhof and Levy-Dorn, Mendel and Selig in regard to wrestling, Moritz as far as bicycling is concerned. Grunmach and afterwards de la Camp found, that even a maximum of physical exertion does not produce any dilatation of the normal heart. Later on Kienböck, Selig and Beck gave a report about acute diminution of the heart after a trying swimming race and other physical exertions. Dietlen and Moritz came to the same results in regard to bicycling. Before that, de la Camp and Freund had observed the same thing with neurasthenia cordis. Dietlen reported about tachycardia paroxymalis which in 2 out of 3 cases had produced a slight diminution of the heart during the attack, and Th. Grödel who four times in 56 cases detected a very slight diminution of size. On the other hand Schieffer, Dietlen, Moritz, Kienböck and his collaborators have all found, that with continued over-exertion the dimensions of the heart gradually increase. A pathological heart does not become enlarged, as de la Camp reports, by a *single* over-exertion. Grunmach, Moritz, Bickel, Bingel, Hoffmann and de la Camp, all state that alcohol, morphium, hydrate of chloral, chloroform, caffeine, nicotine, etc., have no influence on the size of the heart. Moritz states that atropine produces a great diminution of the heart. The influence of various infectious diseases upon the size of the heart has been described by Schieffer and, with more details, by Dietlen. During attacks of stenocardia and bronchial asthma, diminutions of the heart have been detected by Kienböck, Moritz, Götzl, Dietlen. Observations in regard to the influence of various therapeutic treatments have also been made. Rimbach saw the heart decline after manual massage, Rumpf on introducing oscillating currents into the body, Selig after vibration massage and Schott after one gymnastic exercise (?!), whereas I have stated that any considerable change in the size of the heart cannot be produced by gymnastic exercises. Schott and also Kingscote have observed a diminution of the heart after a single carbonic acid bath; whereas Grunmach and afterwards Th. Grödel and myself could not detect this. Quite recently Beck and Dohan have reported that the heart becomes enlarged through cold baths and smaller through hot baths. In conclusion may

be mentioned the observations made as to the changes in the size of the heart in connection with abnormal form of the thorax, especially in scoliosis and in chronic diseases such as tuberculosis.

It has not been possible for me, in the limited space at my disposal, to give an exhaustive description of all that *x*-rays can do in examining the heart. The facts I have stated, however, will prove that the Röntgen rays have considerably advanced our knowledge of the physiology and pathology of the heart, and that we are entitled to expect still greater progress. In conclusion, I wish to lay stress upon the fact that a Röntgen diagnosis of the heart can never stand alone, but only in connection with all the other clinical methods of examination. It is merely to supplement and improve them. How much orthodiagraphy has done, in this respect, for improving percussion is sufficiently proved by the numerous works on the subject.

TREATMENT OF CARDIAC DISEASE IN CHILDHOOD.

By ISAAC A. ABT, M. D., of Chicago.

In a brief paper on the treatment of cardiac diseases of infancy and childhood, it will not be possible to cover the entire field. It will, however, be the aim to point out some of the striking differences which exist between the cardiac diseases of infancy and childhood and adult life; and call attention to the most important points in the treatment.

The blood-pressure in the child's cardiovascular system is relatively low. It is an old observation, credited to Beneke and verified by Baginsky, Von Dusch, Bednar, Engel and others, that in childhood the cardiac cavities are small and the arterial bed is wide. At about the time of puberty the condition becomes reversed and the adult type of large heart and relatively small arteries is established. It may be noted in passing that it is at the period of puberty that so many children show signs of failure in compensation. Possibly the change in cardiac function will explain the decompensation at this time. Little can be said of, and much less can actually be done in the congenital heart affections, and consequently their treatment will not be brought up for consideration.

The most frequent cause of acquired heart disease in childhood is rheumatism, though Concetti inveighs against the rheumatic theory. He believes that some children are congenitally predisposed to the acquirement of cardiac affections; and for this reason he considers that some children are born with a cardiac dystrophy, which predisposes to cardiac inflammation. While we must concede the possibility of some children showing greater resistance against heart disease than others, nevertheless the clinical fact, that heart disease is for the most part a rheumatic inflammation, is well established. I have seen several instances where all of the children of a family fell ill at different times with rheumatism and subsequently were attacked with inflammatory cardiac affections. Chorea should not be ascribed as an etiological factor, because it is generally agreed that chorea, like the cardiac affections, is in most cases a manifestation of rheumatism. Rheumatism is not the only cause of acute cardiac disease.

Acute follicular tonsillitis bears a close and undoubted causal relation to endocardial inflammation. Scarlatina, pneumonia, and the other acute infections, as typhoid, measles, and variola, are occasionally causative factors. Gonorrhea, which is comparatively rare in children, does not have the importance in the production of this variety of inflammation that it has in adults.

In my series of cases observed at the dispensary, scarlatina seemed the etiological factor in 9 out of 30 cases. This is a large percentage, and is to be explained by the fact that scarlatina had been very prevalent in the neighborhood of this dispensary.

The tuberculous endocarditis of general miliary tuberculosis is not a common condition.

Rheumatism is rare under three years of age and under two years is almost unknown. It occurs with increasing frequency after the sixth year. Nevertheless, malignant endocarditis does occur even in infancy as a result of sepsis. In children, the rheumatic affections of the joints may be very indefinite. The child may complain only of slight pain, or there may be some painful affections of the limbs, which are interpreted as growing pains. The rheumatic manifestations may appear so mild and ill-defined that they escape detection, and yet before one is aware, the child may be attacked with breathlessness, precordial distress, and the physical signs of a valvular lesion. I recently saw a little fellow of six years of age who complained for several days of severe headache, frontal and occipital neuralgia, and somewhat obscure abdominal pain, together with moderate elevation of temperature. Several days elapsed before joint pains were complained of. About this time he had slight dyspnea and precordial pain; the physical examination revealed some enlargement to the right, with a moderate hypertrophy to the left, and a soft, blowing mitral systolic murmur.

In children as in adults endocarditis may be divided into the simple and the malignant, or septic. The former occurs usually as a manifestation of rheumatism, scarlatina, pneumonia and other infections. It usually leads to valvular lesions. Septic endocarditis usually occurs in association with some septic process in another part of the body, which leads to more or less erosion of the valve, and usually terminates fatally. The left side of the heart is more frequently involved than the right.

In children, the inflammatory process is not always confined to the endocardium. Indeed, the myocardium and pericardium are sometimes simultaneously involved, leading to a condition which the English writers have aptly termed "carditis."

Pericarditis is frequently associated with acute endocarditis. Its presence is made manifest by the occurrence of pain, though in the subacute variety of pericardial inflammation there may be little or no pain, and children may be up and about during the entire attack. Pericarditis, in association with acute endocarditis, usually renders the course of the disease more severe and makes the immediate, as well as the remote, outlook for recovery more unfavorable. Children with acute peri-endocarditis may show great nervousness and delirium. The temperature is high and dyspnea considerable, the face pale and the expression anxious.

In pericarditis the heart is usually dilated, the heart muscle being soft and flabby and showing well-marked inflammatory changes. It is due to

this "carditis" that cardiac dilatation is almost universally present. It is because of the inflammatory and degenerative changes which occur in the cardiac muscle, that pericarditis is an unfavorable complication. The increase in cardiac dulness is one of the earliest physical signs. The dulness may extend upward as far as the second intercostal space and for an inch outside the nipple line and an inch or more external to the right sternal line. It is frequently thought that this increase in size is due to an effusion. In a certain proportion of cases this is true, but, in the vast majority of instances of rheumatic pericarditis, the increase in size of precordial dulness is to be attributed to cardiac dilatation.

Poynton and Lee show, from an analysis of the post-mortem records of 150 cases of fatal rheumatic heart disease in children, that cardiac dilatation is usually present and marked excess of pericardial fluid is rare. In only 12 cases out of 150 was there an excess of pericardial fluid amounting to more than two ounces. Out of 79 cases of paracentesis pericardii collected by Dr. Samuel West, only eleven were of rheumatic origin, and in only one of these eleven was the effusion large in amount. Of the whole number of patients, only four were under the age of twenty, and there was no fluid.

Acute myocardial inflammation is not infrequent in children. It occurs with the various infectious diseases: diphtheria, typhoid, scarlet and influenza, and this group may be spoken of as infectious myocarditis. Toxines of diphtheria have a peculiar and pernicious influence upon cardiac muscles. The toxic products of the diphtheria bacillus tend to combine early with the muscle cells, though they may remain latent for a time. They tend sooner or later to diminish the tone and strength of the heart and to produce disturbances of rhythm, eventually causing dilatation and weakness of the myocardium. Diphtheritic myocarditis occurs in 10 to 20 per cent. of all cases of diphtheria. The symptoms become most marked during the second or third week of the illness, sometimes during the sixth to the tenth week of the convalescence. These patients frequently complain of a feeling of oppression in the chest, or a pain over the liver. They vomit so frequently as to remind one of a peritonitis, or of an obstruction of the bowels. The pulse shows arrhythmia and frequently the heart discloses no other objective sign, though dilatation to the right and left is not infrequent. A certain amount of nephritis is nearly always present. Neither typhoid nor scarlet produces such marked myocardial symptoms as occur in diphtheria.

Influenza is capable of producing myocardial inflammation. The severe forms of inflammation in influenza seem to affect those who have had a previously weak heart, or who are obese or debilitated.

In the prophylactic treatment of this group of acute cardiac affections, we stand wellnigh helpless. It may be said that children differ materially as to the degree of resistance of the cardiac structure against disease. Perhaps we may be allowed a flight of the imagination. In one instance,

the heart muscle is composed of fibre whose quality represents strength, resistance and durability, while, in another instance, the fibre is of a quality low in strength, inferior in resistance and poor in durability. The quality of this fibre may be influenced by a variety of factors. It may be congenitally poor; it may have acquired an inferior quality because of injudicious or unwise feeding during the first years of life. The patient may be obese and the heart muscle infiltrated or surrounded by fat or relaxed from want of bodily exercise. The real prophylaxis of cardiac disease, if it is at all possible to conceive of such, would consist of increasing the resistance of the heart by strengthening its fibre. To do this the individual should take a fair amount of bodily exercise. Just as the skeletal muscle may be developed and hardened to perform feats of strength or to do work, so the cardiac muscle may be strengthened by graduated exercise. This is advised particularly in weakly children, or those who come from parents who are feeble or have constitutional disease or taints. The form of exercise to be suggested is quite immaterial and may consist of gymnastics, swimming, bicycle-riding, rowing, skating, or playing games in the open air. On the other hand, particularly in children, over-exercise may defeat the very purpose for which it was intended. Clinical records are complete with cases of cardiac dilatation due to overstrain. Valuable chapters have been contributed to medical literature on the production of hypertrophy and dilatation induced by prolonged marches, Marathon races, immoderate feats of strength and excessive or violent work or play. Here may be mentioned football as played by immature boys. It may be stated as an axiom that such exercise may be considered healthful which is not carried to the point of fatigue. All exercise, which exceeds this point, ceases to be beneficial.

In the same way, the nutrition of the body may be considered in the prevention and production of cardiac disease. The child, who is receiving a well-balanced diet with a sufficient amount of carbohydrate food and vegetables, and with no excess of proteid, tends to resist in a degree the functional, as well as the inflammatory, cardiac affections. Those children, who are improperly nourished and more or less in a condition of starvation, or those recovering from acute infectious diseases or from gastro-intestinal disorders, offer correspondingly less resistance against cardiac affections. In older children alcoholic drinks should be prohibited.

Frequent bathing, with cool sponging or showers, produces a certain degree of "hardening."

In this modern era of "fresh air" and "sleeping porches," a word of warning should be sounded. Not every child can bear with impunity undue exposure to cold and all kinds of weather. We frequently see children attacked by rheumatism in whom the hardening process has been carried on too zealously.

Since it is a well-recognized fact that acute and recurrent tonsillitis is frequently the forerunner of rheumatism and cardiac disease, children thus affected should have their tonsils and adenoids removed. During an attack of tonsillitis the salicylates should be energetically administered.

A patient, who is suffering from rheumatism or ill-defined pain such as is sometimes described under the caption of "growing pains," should be treated actively and early with one of the salicylate preparations.

In case of diphtheria, anti-toxin should be administered early and in sufficient dosage to neutralize the toxine. Myocardial attacks in diphtheria occur early, and if treatment is to be effectual, it must anticipate this possibility.

TREATMENT OF ACUTE ATTACK.

In all varieties and degrees of acute cardiac disease, the most important element in treatment is rest in bed. This statement cannot be made too emphatic. In the mild cases it is surprising what degree of resistance parents offer to this plan of treatment. One can almost hear them say, "You don't know the child; you can never keep him in bed." Almost any child can be put to bed, given a few toys and be left to amuse himself. Even in this respect, great care must be taken, lest he over-exert himself by play. The most complete rest that is possible should be enjoined. The child should be kept in bed until the pulse is nearly normal in frequency and tension. Very frequently the arrhythmia and the initial insufficiency which is caused by dilatation will disappear. Four to five weeks is as a rule the minimal period required; not exceptionally, eight to ten weeks will be necessary. In the myocardial disease produced by diphtheria, great caution should be observed in permitting the patient to leave his bed. Sudden syncope and death may occur upon slight exertion.

Before the patient is actually allowed to leave his bed, he should be permitted to sit up for an hour or two each afternoon. In a few days more he may be permitted to carry on some gymnastic practice. Moderate dumb-bell exercise for five or ten minutes may be employed. The duration of this should be gradually increased. When the patient is allowed to get up, his exercise should be restricted and a certain portion of the day be spent in bed or in the half-recumbent posture. After several days, he may be allowed to climb four or five stairs, under pulse control. Carbon-dioxide baths at this time tend to increase the strength of the heart muscle and to diminish passive congestion. The patient should not be given his full freedom for a considerable time. He certainly should not be allowed to join his playmates on the playground until his pulse indicates a return of tonicity and strength of cardiac muscle. In cases where the pericardium is involved, or where the cardiac action is frequent or tumultuous, an ice-bag should be placed over the heart. If rheumatic

pain or arthritis continues, salicylates should be pushed energetically. Of the salicylates, the sodium salt, salicin or aspirin (acetyl salicylic acid) are the most reliable. For a child six or seven years of age, twenty grains of the sodium salicylates or salicin may be given in twenty-four hours. They should be combined with an equal quantity or twice the amount of bicarbonate of soda. The addition of the soda has been suggested, because it is believed that continual use of the salicylic acid derivatives may produce acidosis, with the symptoms of vomiting, rapid and superficial respiration, and drowsiness or coma. Observant of this precaution, however, children bear the salicylates well. Children of ten years or older may be given thirty or forty grains of salicin or sodium salicylate in twenty-four hours. Aspirin is useful and its effect prolonged, though it should not be combined with an alkali. It is true that the preparations of salicylic acid will not assist in the repair of valves which have been damaged, nor cause the absorption of pericardial exudate, nor mitigate the effect of myocardial inflammation. The damage which has already been produced cannot be remedied by the use of any known drug, but we have reason to think that the use of salicylates, if given sufficiently early, will neutralize the effect of the rheumatic poison and thus minimize cardiac inflammation. It may be said, too, in this connection, that relapses of rheumatism, however mild, should at the moment of reappearance receive most vigorous treatment.

Heart tonics are not required in every case. Their use is indicated where there is evidence of cardiac weakness. This applies to myocarditis as well as to the endo- and pericarditis. Of all the drugs in vogue, preparations of digitalis prove most efficient. Digalen or tincture of digitalis in two or three drop doses, three or four times daily for a child of six or seven years of age, are valuable remedies. As concerns the comparative value of digitalis and other cardiac tonics, it may be stated, as a general proposition, that digitalis is the most reliable of all the known remedies, and that if it fails, no other will succeed, though some authorities maintain that strophanthus is of decided value in stenosis and severe dilatation.

McKenzie says that digitalis is useful in those cases of heart failure where there is dilatation with healthy muscle fibres, that have become exhausted in an endeavor to overcome abnormal resistance. In cases of dilatation of the heart with a weak and insufficient systole, its action is almost specific. The drug is of very little use when the dilatation of the heart is due to relaxation of the muscle fibres. The degree of reaction is an index of the extent to which degeneration has gone on. Digitalis is not indicated in simple tachycardia or in cases of arrhythmia. For the fever of acute endocarditis no special treatment is required. The salicylates already referred to tend to control the temperature. Tepid sponging may be employed when there is fever with restlessness. If the patient is extremely restless, with dyspnea and pericardial distress, small

doses of codeine, 1/20 to 1/12 grain for a child of six years, or morphine, 1/60 to 1/30 grain hypodermatically, or 1 to 2 grain doses of Dover's powder, repeated three or four times daily, if necessary, give the most prompt and striking relief.

When the acute stage is terminated, after a prolonged rest in bed, the child should tentatively be allowed to take short walks; all violent exercise must be prohibited, resistance exercises may be given, and a considerable period of time should elapse before the child is permitted the full range of its physical powers and activities.

The danger of producing chronic invalidism and hypochondriasis is not to be lost sight of. Nevertheless, in those cases where the valvular defect is extensive or the myocardial degeneration is marked, the limitation of physical effort is of paramount importance.

Broken Compensations.—Sooner or later, in most cases of valvular lesion, some disturbance of compensation will occur. If passive congestion of other organs or loss of cardiac tone, or if dilatation occurs in a patient who has previously suffered from a myocarditis or a valvular lesion, he should be placed in bed and as far as possible, physical and mental rest should be enjoined. In most of such cases the use of digitalis is indicated. The occurrence of edema or effusions into the serous cavities should be treated by diminishing the fluid intake, continuing the use of digitalis, stimulating elimination through the skin and by the administration of laxative drugs and diuretics. Diuretin may be given in two or three grain doses for children of six or seven years, and is one of the most reliable diuretic drugs. It was Stokes, who long ago advised the use of calomel for the diuretic effect. Small doses of 1/10 to 1/16 of a grain should be given three times daily for three days, though it should be used with considerable care, especially in those cases where there is kidney involvement. It is rarely necessary to resort either to puncture of the skin, or peritoneal cavities, for the relief of fluid accumulation.

The much-vaunted strychnia is valuable in those cases, acute or sub-acute, which depend upon disturbance of cardiac innervation, particularly in cases of post-diphtheritic myocardial involvement, and the influenza myocardial affections. It is doubtful whether strychnia is a real cardiac muscle stimulant. It was H. A. Hare who wrote some years ago on strychnia as a cardiac tonic. He compared its use to whipping a horse that was going full speed. Strychnia may stimulate by increasing the work done by the heart, not necessarily increasing its force; and like the horse that is being whipped, the heart is likely to stumble and fail.

In cases of sudden syncope, camphorated oil, hypodermatically, may be used to relieve the acute cardiac failure.

In cases of chronic pericarditis with obliteration of the pericardial cavity, the heart may be firmly adherent to the sternum and ribs anteriorly and to the spinal column posteriorly. Thus during each systole an extra strain is placed upon the heart muscle. To overcome this condition Brauer

has suggested his operation of cardiolysis. It consists of resecting the ribs which cover the heart; the sternum is not removed. By this operation the interference with heart action is considerably lessened and favorable results have been reported. Brauer suggests that good results can be obtained only when the heart muscle itself has not been materially weakened by disease. If the heart does not maintain sufficient strength to retract the chest wall, after removal of the ribs, the operation is useless.

THE HYDROTHERAPEUTIC TREATMENT OF HEART DISEASE.

By JOHN M. SWAN, M. D., of Watkins, N. Y.,
Medical Director of The Glen Springs.

Excluding diseases of the pericardium and of the mediastinal tissues, which may affect the heart, the chronic diseases of that organ may be divided into chronic valvulitis in its various forms, and disease of the myocardium. Chronic valvulitis is the result of a previous acute endocarditis, or primary fibrosis, or of a rupture of one of the leaflets of one of the valves due to trauma. The condition of the valves in a case of chronic valvulitis is the result of cicatrization of the acute lesion. The resulting disturbance in the passage of the blood through the various chambers of the heart and into the great arteries, the aorta and the pulmonary artery, produces changes in the heart muscle which are of grave importance to the circulation. In order to provide for the needs of the systemic circulation in particular, the myocardium undergoes a local or a general hypertrophy, sometimes with and sometimes without dilation of one or more of the chambers. An hypertrophied heart muscle cannot be considered normal and sooner or later degenerative changes occur in it which result in further circulatory disturbances and produce the symptom-complex known as lost or broken compensation. The change may be a fibrosis, fragmentation, or fatty degeneration, or any combination of these morbid processes.

Apart from the changes in the heart muscle dependent upon valvulitis, that muscle may become diseased in the course of any of the acute infectious diseases, diphtheria, typhoid fever, influenza and malaria, for example. The form of change seen in these cases is the result of cloudy swelling and is known as *parenchymatous myocarditis*. The myocardium may become diseased by the extension into it of the fibroid changes which accompany general arteriosclerosis, the coronary arteries in this instance usually forming the starting point for the increase of the connective tissue of the heart muscle at the expense of the muscle tissue; *cardiac-fibrosis, fibroid myocarditis*. The myocardium may become damaged by the deposit of fat in the normal connective tissue of the muscle in cases of general obesity; *fat heart*.

Fatty degeneration of the myocardium is the last stage of the parenchymatous form of myocardial alteration, and of the hypertrophy due to valvulitis, renal disease, and overwork.

Dilation of the heart without compensatory hypertrophy is usually accompanied by important changes in the myocardium.

The functional capacity of the heart depends entirely upon the condition of the heart muscle and not at all upon the disease of the valves. So in the therapeutics of chronic heart disease, an estimation of the integrity of the muscle is of first importance. When the muscle begins to fail either from changes in the muscle fibers, from increase in connective tissue, or from the deposition of fat, the therapeutic problem is to restore that muscle as much as may be to its functional integrity.

This contribution is not concerned with the possibilities of drug administration, as important as that is, but to point out the results that can be obtained by the use of rest, hydrotherapeutic measures, and exercises. The combination of these three methods of treatment is commonly known as the *Nauheim treatment* of chronic disease of the heart. The treatment has been in use since 1835; but has been prominently brought to the attention of therapeutists generally since about 1880, through the writings of Beneke, Grödel, the Schotts, and many others. The chief hydrotherapeutic method employed at Bad Nauheim is the immersion of the patient in a full bath of a natural brine which is charged with free carbonic acid gas. The important constituents of the Nauheim bathing waters are sodium chlorid and calcium chlorid. The Nauheim physicians have always held that artificial baths can be prepared which will accomplish good results if properly managed; but there is an advantage in the employment of a water in which the solution of the saline ingredients has been brought about by natural processes. The Nauheim bathing waters contain the following percentages of sodium chloride and calcium chloride: *Grosser Sprudel*, sodium chloride, 1.95 per cent., calcium chloride, 0.13 per cent.; *Friedrich Wilhelm Sprudel*, sodium chloride, 2.71 per cent.; calcium chloride, 0.27 per cent., and *Ernst Ludwig Sprudel*, sodium chloride, 2.27 per cent., calcium chloride, 0.24 per cent.

At The Glen Springs a natural brine containing sodium chloride, calcium chloride and other mineral ingredients is used for the administration of carbonated brine baths. The water is obtained from an artesian well 1500 feet deep. It is pumped into large reservoirs from which it is piped to the bath rooms. As the water flows from the well into the tanks it has a temperature of 56° F. It is usually perfectly clear and colorless and contains numerous bubbles of gas of varying size. It is strongly saline to the taste and is without odor. After standing for a time it becomes cloudy and begins to deposit a precipitate which is dark grey in color with a tinge of yellow. After standing for twenty-four hours this deposit collects in the bottom of the vessel as a dirty brown flocculent sediment, and the supernatant water is cloudy with the suspended particles of this precipitate. Under the microscope this precipitate is seen to be composed of fine, yellowish granules; large, irregular, reddish masses, amorphous in character; colorless amorphous masses,

and some large blackish masses. A specimen allowed to stand for 48 hours gave 0.1572 grm. of this precipitate to the liter. The precipitate gives the qualitative reactions for iron. The salimeter registers 65. The water is neutral to litmus, to phenolphthalein, and to Congo red.

An analysis made in 1910 by Professor E. M. Chamot, of Cornell University, gave the following results:—

	Grams per Liter.
Total Solids.	213.8
Loss on Ignition.	38.6
Silica.	0.79
Oxides of Iron and Aluminum.	0.03
Calcium (Ca).	14.9
Barium (Ba).	0.03
Magnesium (Mg).	4.2
Nitrogen (N) as NH_4	0.85
Sodium (Na).	47.3
Potassium (K).	0.008
Lithium.	Trace
Chlorine.	111.0
Carbonic Acid (CO_2) half-bound.	0.01
Carbonic Acid (CO_2) free.	0.17
Sulphuric Acid (SO_3).	Trace

"These constituents are in my opinion combined as follows":—

	Grams per Liter.	Grains per U. S. Gallon.
Total Solid Residue.	213.8	12,400.
Organic and Volatile Matter.	38.6	2,238.
Colloidal Matter.	0.8	46.
Calcium Chloride (Strontium Chloride).	41.2	2,489.
Magnesium Chloride.	16.3	945.
Barium Chloride.	0.025	1.
Barium Bicarbonate.	0.056	3.
Ammonium Chloride.	3.2	185.6
Sodium Chloride.	120.0	6,960.
Potassium Chloride.	0.015	0.8
Lithium Chloride.	Trace	Trace
Sulphates.	Trace	Trace
Carbon Dioxide in Solution.	0.17	9.

In this brine there is 12 per cent of sodium chloride and 4.12 per cent of calcium chloride. By diluting it with five volumes of fresh water we get a water which contains 2 per cent sodium chloride and 0.68 per cent calcium chloride. By using one volume of this brine and six volumes of fresh water, we get a water which contains 1.71 per cent sodium chloride, and 0.58 per cent calcium chloride.

By varying the dilution and by adding carbon dioxide gas by artificial means we are able to employ carbonated brine baths of suitable strength for the treatment of chronic heart disease. The patient is immersed in

the bath, the temperature of which is varied according to well-known indications, for a period varying from four to fifteen minutes, he is then carefully dried and required to rest in bed for one hour. The baths are given on alternate days, so that a full course requires six weeks.

The effects to be expected following the carbonated brine baths in a case of cardiac incompetency are (1) diminution in the size of the heart, (2) slowing of the pulse, (3) reddening of the skin, (4) slowing of the respiration, (5) reduction in the size of the liver, if that organ is the seat of a passive congestion, (6) improvement in the muscular quality of the systolic sound of the heart, (7) the disappearance of a hemic murmur or of a murmur due to dilation of an orifice, and (8) increase in the intensity of an organic murmur dependent upon valvular defect or deformity.

As an example of the diminution of the size of the heart following a course of these baths, the case of a male, aged sixty-three years may be referred to. The patient presented a dilation of the heart following the sudden strain of helping to lift an automobile. When first seen the cardiac dulness extended from the third rib to the fifth interspace and from the right edge of the sternum to one and one-half inches outside the midclavicular line, a transverse diameter of eight and one-half inches. After the completion of the treatment the cardiac dulness extended from the third rib to the fifth interspace, and from the right edge of the sternum to one-half inch outside the midclavicular line, a transverse diameter of seven and one-half inches.

In another case, that of a male, aged fifty-two years, presenting mitral regurgitation, hypertrophy of the heart, and dilation of the heart, the dulness before the institution of treatment extended from the fourth rib to the seventh interspace, and from the right edge of the sternum to 1 inch outside the midclavicular line; a transverse diameter $8\frac{1}{2}$ inches. After the completion of the course of baths the cardiac dulness extended from the fourth rib to the seventh interspace and from the right edge of sternum to $\frac{1}{2}$ inch outside the midclavicular line. Transverse diameter 8 inches.

The accompanying figures are submitted to show the effect of the baths on the pulse rate. The patient was a female, aged sixty-five years, who had hypertrophy with dilation of the heart, accompanied by an extensive chronic bronchitis and chronic dry pleuritis.

Number of Bath.	One Hour			
	Before.	During.	After.	After.
8.	103	90	98	79
9.	107	80	93	80
10.	100	80	78	74
11.	98	80	84	72
12.	94	75	82	70
13.	89	70	76	73
14.	101	88	98	91

15.	70	65	71	76
16.	85	75	77	77
17.	80	75	81	76
18.	76	70	86	74

In the case of a male, aged thirty-six years, who had mitral regurgitation and aortic regurgitation, the accompanying figures were obtained:—

Number of Bath.	Before.	During.	After.
1.	108	100	100
2.	116	96	100
3.	102	96	94
4.	110	106	96
5.	100	96	88
6.	96	92	88
7.	90	84	82
8.	94	96	86
9.	92	92	80
10.	92	86	84
11.	84	84	84
12.	90	86	80
13.	84	82	84
14.	90	88	84
15.	90	88	84
16.	92	90	78
17.	100	100	84
18.	90	86	84

In the case of a male, aged seventy years, who had dilation of the heart with myocarditis, the liver dulness before the baths extended from the fifth interspace to the costal margin; the edge of the organ was palpable. At the conclusion of the treatment the liver dulness extended from the sixth rib to the costal margin. The edge of the organ was not palpable on deep inspiration.

In the case of a male, aged sixty-eight years, who had hypertrophy of the heart, with fibroid myocarditis and mitral regurgitation, the liver dulness before the baths extended from the fifth interspace to one inch below the costal margin; the edge of the organ was palpable but not tender. After the baths the liver dulness extended from the fifth interspace to the costal margin; its edge was palpable but not tender.

In the case of a male, aged thirty-six years, who had mitral regurgitation and aortic regurgitation, the liver dulness before the baths extended from the sixth rib to the costal margin; its edge was palpable, but not tender. After the baths the liver dulness extended from the sixth rib to the eighth interspace; its edge was not palpable and there was no tenderness.

The effect of the carbonated brine baths on cardiac adventitious sounds is dependent upon the influence of the baths on the cardiac musculature. The muscle is improved in its functional capacity, it contracts more slowly,

with more of that element which gives the muscular quality to the systolic sound, and, if the organ has been stretched the dilatation is lessened. If a murmur is pericardial we would expect it to become louder with improvement in the contractile force of the heart muscle. If the murmur is due to chronic valvulitis with thickening and deformity we would expect the increased force of the contracting muscle to increase the intensity of the murmur and to make its transmission better defined.

If the murmur is dependent upon dilation of one of the orifices of the heart the improvement of the muscular wall of the organ with diminution of dilation should cause the murmur to disappear. A hemic murmur should disappear.

We consider that the muscular quality of the systolic sound of the heart is an important indication of the functional capacity of the myocardium. In a heart which produces a full toned "lub" as the characteristic systolic sound we may assume that the contraction is energetic and competent. On the other hand, any diminution in the quality of this sound indicates a weakness in the contraction and a lack of competency on the part of the myocardium. The interpretation of the character of the systolic sound is, of course, dependent upon the training of the ear of the examiner, and is subject to the influence of the personal equation to a very great extent, except in the extremes of weakness.

The chief indication for the use of carbonated brine baths in the treatment of chronic heart disease is in cases of myocardial insufficiency with low blood pressure. In such cases we expect to get a slowing of the pulse, an increase in the muscular quality of the systolic sound of the heart, and an increase of blood pressure. If, in addition, there be dilation of the heart due to loss of tone of the muscle, we expect to see the transverse diameter of cardiac dulness reduced. If the dilation affects the mitral ring so that there is a functional insufficiency of the mitral valve with the production of a soft systolic murmur transmitted into the axilla, we expect that murmur to disappear with the contraction of the heart to more nearly its normal size and with improvement of the tone of the myocardium.

In cases of myocardial degeneration following the compensatory hypertrophy dependent upon valvulitis we look for little or no change in the area of cardiac dulness outlined by percussion, but with improvement of the muscular tone we expect the valvular murmur to increase in loudness and distinctness and in definiteness of transmission. We look upon the increase in the murmur to be indicative of improved functional capacity of the heart.

In cases of parenchymatous myocarditis following the acute infectious diseases, the hydrotherapeutic treatment should improve the muscular quality of the systolic sound, raise the blood-pressure, and slow the pulse.

In cases of nervous and functional disorder of the heart, the carbon-

ated brine baths sometimes are productive of benefit and sometimes fail. If the disturbance is dependent upon toxic or reflex influences, the treatment is likely to be futile unless the reflex or toxic cause is first removed.

In cases of fibroid myocarditis with high blood-pressure and evidence of general arteriosclerosis, carbonated brine baths, if given at all, should be very carefully watched and should be stopped if the symptoms of high blood pressure increase: tinnitus, vertigo, precordial pain, headache, full, strong, incompressible pulse. Usually in such cases the temperature of the baths should be kept at or above 98° F., the stronger brines should not be used, and the carbon-dioxide gas should be omitted.

In cases of fat heart, treatment with cold carbonated brine baths is best omitted, provided the myocardium is in good condition. Treatment calculated to reduce the weight of the patient and to improve his general metabolism, combined with a general obesity diet, should be instituted.

Carbonated brine baths are contraindicated in cases of advanced arteriosclerosis, chronic nephritis, thoracic and abdominal aneurysm, and in the terminal stages of broken compensation with edema.

In cases of nephritis the cautious employment of the weaker brines, warm, without carbon dioxide, alternating with some form of eliminative treatment, such as the electric light bath or the vapor cabinet bath, may be tried with close watchfulness. Particularly should the percentage of albumin in the twenty-four-hour specimen of urine be determined daily. If, however, the pulse increase in rate, albumin increase in percentage, edema increase in amount, the brine baths should be discontinued and dependence be placed on eliminative treatment, rest, diet, and digitalis.

The cases of arteriosclerosis should be handled in the same way. If the blood pressure increase in the brine baths they should be discontinued.

In cases of the terminal stage of broken compensation the effort necessary on the part of the patient to get into and out of the tub will be productive of deleterious results.

Accessory hydrotherapeutic and mechanotherapeutic procedures.—In cases complicated by acute, subacute, or chronic bronchitis or pulmonary congestion much benefit is obtained by alternating the carbonated brine bath with a vapor bath into which the brine of the Nauheim spring is sprayed. A specially constructed room is prepared into which steam is led in such a way that the brine is sprayed into the compartment in an intimate mixture with the steam. The patient sits in a reclining chair, with a cold towel about his head, and breathes the air saturated with moisture and impregnated with the finely divided saline ingredients of the brine. Such a treatment is also of value in cases of acute and chronic laryngitis accompanying chronic cardiac disease.

After the diseased myocardium has had a chance to recuperate partially from the strain put upon it by the ordinary or the extraordinary demands of the daily habits of an individual patient, in order to put it in a condi-

tion to perform its function in as nearly as possible a normal manner, it is wise to undertake to provide for the exercise of the muscle under careful supervision.

The principle involved is the same as that concerned in the development of a skeletal voluntary muscle; exercise of the muscle to be developed. It is known that exercise in a normal individual increases the heart rate and hence carefully regulated exercise is the method to be adopted for improving the tone of the cardiac musculature.

Two methods are available; that of Schott, known as *Resistance Exercise*, and that of Oertel, known as *Hill Climbing*.

In the former the patient is required to make certain movements with his arms and legs against resistance applied by an attendant.

There are, all together, eighteen exercises employed and the degree of resistance varies with the character of the pulse; at first it is slight, but as the strength of the myocardium improves it is increased. After each movement the patient rests for thirty seconds or a minute.

In the later the patient exercises his myocardium by walking on hills the degree of elevation of which is known, the distance is known; and opportunity for rest is provided at suitable intervals.

At The Glen Springs we employ the following routine distances and grades: one-sixth mile, elevation twenty-three feet; one-fourth mile, elevation forty-three feet; one-fourth mile, elevation sixty-six feet; one-half mile, elevation one hundred and thirteen feet; two-thirds mile, elevation one hundred and six feet; four-fifths mile, elevation one hundred and thirty-six feet; three-fifths mile, elevation one hundred and thirty-six feet; two-thirds mile, elevation one hundred and forty-six feet; five-sixths mile, elevation one hundred and sixty feet; seven-eighths mile, elevation one hundred and ninety-three feet.

The best results are obtained when these methods are adopted after the course of carbonated brine baths is finished. In cases, however, in which it is advisable to get a patient back to his daily routine at the earliest possible moment they may be begun at the end of the second week of treatment with the baths, provided the cardiac action will allow it, and carried along on the alternate days, until the end of the six weeks.

Diet.—During the administration of a course of carbonated brine baths the patient should be given a mixed diet of easily digested and readily assimilated constituents with a caloric value of at least 2500. It is unnecessary to make any great restriction or to deprive a patient of articles of diet to which he is used, and of which he is fond, unless they are distinctly harmful. The accompanying list is used at present at The Glen Springs:—

Milk or buttermilk, two pints a day.

Zwieback, whole wheat bread, graham bread, or buttered or milk toast.

Soft boiled eggs, poached eggs, scrambled eggs.

Roast beef, lamb, mutton, chicken or turkey.

Broiled steak or chops.

Baked, broiled or boiled fish without sauce; but no fried fish.

Spinach, string beans, tomatoes, oyster plant, boiled rice, baked potatoes, stewed celery, endives, peas, asparagus, cauliflower, lettuce with Mayonnaise or French dressing. Cream cheese.

Rice pudding, baked custard, tapioca, corn starch pudding, ice cream, stewed prunes, apple sauce, baked apple, preserved peaches, stewed figs.

The patient should not eat:—

Fried food of any kind.

Hot bread or griddle cakes;

Goose, duck, or guinea hen;

Pork or veal in any form;

Rhubarb, cabbage, parsnips, turnips, carrots;

Salt or smoked fish;

Cheese, except cream cheese as already specified;

Fancy desserts;

Entrees, sauces and gravies.

We wish to say a word of caution to physicians who send patients to sanatoria for the hydrotherapeutic and mechanotherapeutic treatment of cardiac disease. It is very unwise to allow the patient to think he can hurry through his baths and return to his customary work in a short time. Usually the patient has been burning his candle at both ends for a long time and he needs to take the full course. Not one day short of six weeks, but preferably ten weeks' treatment is advisable.

It is a mistake to encourage patients with myocardial changes to expect to receive some kind of treatment three or four times a day. A carbonated brine bath on one day, perhaps general massage on the alternate day, with short walks on a level path, accompanied with quiet and relaxation in the open air are attended with the best results. The patient who jumps about from one treatment to another, dressing and undressing three or four times a day, does himself more harm than good.

THE RELATION OF THE TONSILS TO HEART DISEASE.

By ALBERT HENRY BEIFELD, M. D., of Chicago.

Although it is only within recent years that disease of the tonsils—the most important organs of the Waldeyer lymphatic ring—has been associated etiologically with infections of the heart and its membranes, occasional observations were made as early as 1865. Fernet,¹ at that time noted the occurrence of an “rheumatic pharyngitis” and classified “rheumatism of the throat” as part of the rheumatic syndrome, by virtue of which fact he became one of the first to bring to notice the relation of tonsillitis to acute heart disease, Bouillaud² having established the inevitable connection of rheumatic fever and endocarditis and pericarditis. Lasègue,³ saw in the nature of the tonsillitis, with its suddenness of onset, an intensity of local discomfort all out of proportion to the visible signs of the disease, the probability of a following rheumatism.

These communications do not seem to have attracted much attention at the time,—surely not outside France,—since one of the first English clinicians to have published similar observations was Kingston⁴ in 1880. After him, however, the publications have multiplied until at the present time the relationship between these two conditions has been quite generally accepted. Still it requires no more than a cursory perusal of the monograph on rheumatism by MacLagan in the “Twentieth Century Practice” (1895), classified under Nutritional Diseases, to see that there were some who were slow to recognize this coincidence; for, in the 140 pages given over to the discussion of complex theory of origin, clinic, and treatment of this ailment, nowhere is mention made of the tonsil as a possible atrium of infection.

In Germany, strange to say, recognition of the relationship between these two infections did not take place until considerably later, the first reports⁵ being said to have appeared in 1892. Henoeh,⁶ in his chapter on rheumatism, casually remarks the incidence of an occasional preceding tonsillitis. Roos⁷ reports 2 cases and lays stress on the fact that this important element has been neglected. Singer⁸ in 1897 states that of 66 cases of acute articular rheumatism, 26 were preceded by tonsillitis.

As later researches have clearly proved that endocarditis may be caused by the various pyogenic micro-organisms as streptococcus, pneumococcus, staphylococcus, gonococcus, etc., it remained merely to establish the identity of the organism of rheumatic endocarditis. The bacillus of Achalmé has not been found by other investigators; in its place there has been isolated from cases of rheumatism a diplococcus, which seems to stand some-

where between the pneumococcus and the streptococcus. Mantle, Klebs,⁹ Singer and Loeffler have done the pioneer work in this field. Poynton and Payne,^{10 11 12} have been the latest to hold to a distinct organism as the cause of rheumatic fever, and, besides cultivating it from the blood of patients suffering with rheumatic fever, have also isolated it from the tonsils of such patients. Triboulet and Coton¹³ in 1898 produced mitral disease in rabbits by the injection of an organism cultivated from the blood of a patient suffering with acute articular rheumatism, as did Poynton and Payne. Cole,¹⁴ however, was able to produce similar results with the streptococcus and concludes that this organism is the infecting agent.

Study of the tonsil flora has thrown some light on this knotty problem. While Poynton and Payne have found their "micrococcus rheumaticus" on the tonsils, other observers, recognizing that there is much variation of strain, have been willing to identify the cocci found as streptococci. Ruediger,¹⁵ found the streptococcus pyogenes in small numbers in 60 per cent. of apparently normal throats, and, constantly in great abundance in the throats of patients suffering from scarlet fever and tonsillitis. Davis¹⁶ in a careful study of tonsils removed from 45 cases of endocarditis, etc., found that the crypts in almost all cases yielded the streptococcus in pure or almost pure culture, while on the surface the pneumococcus predominated. The virulence of the organisms was evidenced by the production of endocarditis and arthritis on intravenous and intracardiac injection of animals. Interestingly enough, a pneumococcus produced mitral endocarditis in a rabbit, although no heart lesion existed in the patient from whom the coccus was obtained.

The nature of the tonsillitis preceding rheumatic disease is described by most authors as showing a marked degree of injection, and but rarely any pus formation; in other words, such an inflammation as we should expect to be caused by an organism of the streptococcus type. Bachhammer,¹⁷ in 37 post-mortem examinations of cases of septic and chronic recurring and verrucous endocarditis, found the most varied pathological changes in the tonsils, such as pus in the crypts, old purulent and gangrenous tonsillitis, and scars of old lesions. The failure to make control observations, however, weakens the object of the investigator in trying to demonstrate the obligate connection of the lesions and disease of the heart, and of other organs. Guerich,^{18 19} in several interesting communications, has put forth the view that the crypts are the seat of a chronic inflammation, and to this he has applied the term "chronic fossular angina." He believes that lacunæ harbor pathogenic bacteria which may at intervals infect the body through the lymph or blood-stream, reaching the endocardium via the coronary vessels.²⁰ According to his views most individuals have this form of angina; from which source they become infected when for some reason the resistance is lowered.

That bacteria may pass through the intact epithelium is seen in the

work of Stohr.²¹ Grober²² calls attention to the fact that in the act of swallowing, the increased pressure on the tonsils may be an accessory factor in forcing bacteria into the body of the tonsils. Thence, they travel to the regional lymph glands or they may also be caught in the blood-stream and thus enter the general circulation.

At this point a slight digression may be permissible to call attention to the recent views as to the functions of the tonsils. Levinstein²³ reviews the literature, and concludes that the view that these organs play a rôle in the protective mechanism against infection is the most probable one. Good,²⁴ without adducing the slightest evidence of a scientific nature, declares that the early immunization of the individual against infection of the upper respiratory tract is the chief function of the tonsils. However plausible such an explanation may sound, it cannot claim credence, supported as it is by the mere statement of its sponsor.

The difficulty experienced by earlier investigators in isolating an etiological organism in these cases, led to the idea that toxins might be responsible for the manifestations of rheumatism and endocarditis. Such views are presented by Chvostek and Singer.²⁵ The experiments of Fulci,²⁶ however, seem to show conclusively that injections of the most varied bacterial and other toxins, as well as of nucleoproteids and dead bacteria, even when the heart valves were injured, were incapable of producing endocarditic changes.

While the literature abounds in articles on rheumatism, rheumatic endocarditis, chronic ulcerative endocarditis and pericarditis, it is noteworthy that in but few of these is a serious attempt made to establish the fact of the tonsils being or not being the portal of entry of the infection. Poynton²⁷ finds sore throat in 10 (23 per cent.) of 43 cases of rheumatism in children under five years of age, and in analysing 100 cases of suppurative pericarditis takes no account of the possibility of the tonsils being the source of infection. Osler,²⁸ in 10 cases of chronic infectious endocarditis, notes the pre-existence of tonsillar inflammation in but one case, and is satisfied with the mere mention of the fact that there was a history of rheumatism in childhood in 5 cases. Horden,²⁹ in analysing 150 similar cases, states that 72 gave a history of rheumatism, but does not regard the question of tonsillar infection of sufficient importance to refer to it. Ræger,³⁰ on the other hand, noted that in a series of observed cases of tonsillitis 8 per cent. were followed by permanent valvular lesions, without the occurrence of an intermediate rheumatism. Packard³¹ also early reports 5 cases of endocarditis following tonsillitis. Rachford³² describes a case in which, after repeated attacks of tonsillitis, scarlet fever developed with especially severe throat symptoms. Two months after the onset of the disease, a severe tonsillitis recurred and following hard upon it, septic endocarditis which led to the death of the patient. Pearson³³ had a case of streptococcal pericarditis (and colitis) following tonsillitis. Billings,³⁴ in 14 cases of chronic infectious en-

docarditis, was able to establish the tonsils as the atrium of infection in 2 of them. This,³⁵ in a statistical study, found that in 288 cases of rheumatic arthritis, 19 per cent. had had previous tonsillitis, while of 258 cases 15 per cent. developed endocarditis, pericarditis, or both.

As early as 1884, Blyckærts³⁶ advocated the use of sodium salicylate in the prodromal affections of acute arthritis. Since then, as the salicylates have established for themselves a distinct place in the therapy of the rheumatic syndrome, there has grown the feeling that they are of service in diminishing the severity of ensuing cardiac complication. As, however, no convincing proof of this has been brought forward, they are administered on purely empiric grounds. Some attempts at prophylaxis and local antiseptic treatment of the buccal cavity have of course been made, as, for instance, the use of guaiac preparations by Zeuner.³⁷ Paraldehyde troches are also enjoying vogue. Campani³⁸ believes that the brushing the teeth, gums, and tongue each night with sodium bicarbonate will prevent the tendency to recurring tonsillitis. Melzi³⁹ urges the administration of brewers' yeast in sweetened milk. Wadsworth⁴⁰ showed in experiments that alcohol was the only efficient antiseptic against the resistant pneumococcus.

Such methods are of avail, of course, only in attacking the surface micro-organisms. It remained for Guerich⁴¹ to introduce the interesting—if radical—treatment of actually removing the tonsils in all cases of acute articular rheumatism and, indeed, at the first signs of the disease. His methods were quite crude as compared with the simpler enucleation of the present day, a fact which he then realized, especially when he emphasized the disadvantage of tonsillotomy. The idea of removing the tonsils during the height of an acute febrile disease—a grave infection—has not commended itself to the general mind. The author himself calls attention to the "reaction" following the operation and calls it an "experimentally produced articular rheumatism." He does not consider it of the slightest serious import, even though it may last as long as four days. According to the enthusiastic reports of this country practitioner, the course of all cases is, except for the reaction, materially shortened. If this be true, we may assume that the likelihood of cardiac complication would likewise be distinctly diminished. Schichhold⁴² praises this therapy, applying it with discrimination and apparently preferring the more conservative procedure of slitting the crypts in certain cases. Curschmann⁴³ also is impressed with the possibilities of the method. Prym⁴⁴ was one of the first to apply the Bier-Klapp suction method to disease of the crypt. Levinstein⁴⁵ finds that in cases of chronic recurring tonsillitis the searing of the affected crypts with the pointed galvano-cautery (introduced by Voltolini) will often in the most surprising fashion put an end to the infection, even after all other methods have failed. The fact that one treatment will not infrequently suffice causes him to read much good in this relatively simple and harmless intervention.

It would be superfluous to review the literature on the numerous methods of complete enucleation of the tonsils, at present the operation of choice of the American operator. Suffice it to say that the tonsils are at present most often removed because they are enlarged, rather than because when infected they become a grave menace to the individual. There does not seem to be as yet a crystallized opinion that tonsillectomy should be urged as a prophylaxis against cardiac disease.

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THE NEWER HEART REMEDIES.

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In 1874 Schmiedeberg¹ published his method for the isolation of digitalin and digitoxin. His work was hailed with delight by the medical world, for it was hoped that the use of the active principles in the pure state would put an end to the uncertainty of digitalis medication. But the pure drugs did not find favor with the practising physicians; their clinical experience seemed to show that the new drugs did not produce the true digitalis effect obtainable from the old leaf preparations; and although the greater certainty of dosage was felt to be a very valuable factor in the treatment of heart disease, the advantage gained by more accurate dosage was not sufficient to overcome the inefficiency of action, and practitioners therefore returned to tincture and infusion. In the years 1891 to 1894 Schmiedeberg and his pupils carried out a series of careful researches on the pharmacology of digitalin and digitoxin, and, as a result of this work, Schmiedeberg recommended digitalin as a complete substitute for the galenical preparations of digitalis. Again clinical experience differed with that of the laboratory, and although digitalin was more widely used than previously, it could not replace the preparations made directly from the crude drug.

The problem for the chemist and pharmacologist, therefore, was not to isolate active principles, but to improve the whole drug preparations, to produce efficient and permanent leaf powders, or extracts, of known strength and free, as far as possible, from gastro-enteric action.

With this end in view, Golaz,^{2,3} a Swiss apothecary, dialyzed macerations of fresh digitalis leaves first with water and then with aqueous solutions of alcohol in gradually increasing concentration; the process of dialysis lasting fourteen days. Golaz used the utmost care in the selection of his leaves, he collected them in one locality only, taking nothing but the second year's growth and gathering the leaves on bright sunny days so as to insure a minimum of moisture content; he also controlled his product by chemical analysis. By this method Golaz hoped to obtain dialysates of uniform action and free from irritating leaf constituents. The chemical analysis of the dialysates indicating that the product was of uniform strength, Golaz submitted his samples to Prof.

Jaquet for pharmacological verification. Jaquet found, however, that different samples of dialysate differed very widely in physiological action, but by concentrating dialysates which were too weak, *in vacuo*, and diluting those which were unusually strong, Jaquet found it possible to produce preparations of uniform physiological strength.

The dialysates of Golaz are excellent preparations as long as they are fresh; they are readily absorbed and are borne well by the stomach, but unfortunately, they are not permanent.

Jaquet's results stand as excellent proof of the fact that chemical standardization is of no value when digitalis products are concerned. Many other authors who compared chemical with physiological standardization obtained results similar to those of Jaquet. Thus Barger and Shaw⁴ could isolate only one-third of the digitoxin which by physiological analysis was shown to be present in a sample of tincture of digitalis. In another experiment these authors added a known amount of digitoxin to an artificial tincture and succeeded in recovering only one-fourth of the added drug. It is quite obvious, therefore, that in the case of digitalis other than physiological standardization is out of the question.

Of recent years physiologically standardized tinctures and infusions (digitalone, strophanthone) have come more and more into use. When these preparations have been recently standardized they are, of course, vastly superior to the ordinary tincture of unknown strength. But tinctures prepared according to the directions of the pharmacopeia, with dilute alcohol, deteriorate very rapidly, and their standardization is really a waste of time. In order to insure permanence in a tincture it must be prepared with 70 per cent. alcohol. Worth Hale⁵ examined a number of such tinctures and found that they showed practically no deterioration in strength in the course of eight years.

Tinctures prepared with 70 per cent. alcohol and afterwards carefully standardized may be used, therefore, to carry out accurate and uniform digitalis medication. Such tinctures, moreover, represent a purer product than the ordinary pharmacopeial tincture, since the concentrated alcohol, which is used, removes by precipitation a large portion of the useless resinous material. An infusion cannot be made permanent; infusions are not a necessary preparation; and for the sake of accurate dosage it will be better to omit them entirely.

The Germans have always shown a preference for the dried and powdered leaf; it is only natural, therefore, that many German investigators should have attempted to improve the drug in this form. We owe it to the work of Focke,⁶ Siebert,⁷ Ziegenbein⁸ and others that to-day permanent and uniformly active preparations of the powdered leaves may be bought in the market.

Standardized, permanent tinctures and leaf powders fulfil, however, only one of the qualifications of the ideal digitalis preparation; such a preparation besides being of known physiological activity, should not pro-

duce gastro-enteric irritation and should be prompt and efficient in action without exposing the patient to the danger of cumulative poisoning. The gastro-enteric irritation of tincture and powdered leaf are only too well known to practitioners; at times this most undesirable feature of their action makes it impossible to carry digitalis medication to its logical end, the stomach of a patient with heart disease being as a rule particularly sensitive to irritant drugs. This fault cannot be corrected in the tincture as such. In the case of the powdered leaf this purpose has, however, been accomplished by the use of gelatine capsules hardened in formaldehyde.

Sahli found that whereas the ordinary gelatine capsule is dissolved in from five to fifteen minutes by the gastric juice, a capsule hardened in formaline will resist gastric digestion for four or more hours. This discovery led to the introduction of Sahli's well-known "desmoid" capsules. In attempting to use the Sahli capsule for the purpose of administering drugs which caused irritation of the stomach, Rumpel noticed that substances soluble in water were slowly leached out of the "desmoid" capsule long before the capsule itself was dissolved. This was due to the swollen condition of the capsule, which acted as a sort of dialyzing membrane. By using an alcoholic solution of formaldehyde instead of formaline, Rumpel⁹ obtained a capsule which resisted gastric digestion longer than the "desmoid" capsule, without permitting any part of its contents to pass into the stomach. A German pharmaceutical house¹⁰ is now dispensing over 200 different drugs in these capsules of hardened gelatine (trade name: "Gelodurat Capsules"), and among these is a capsule containing digitalis leaf powder prepared and standardized according to the method of Caesar and Loretz (Fol. digit. titrata). These capsules have been employed in a number of cases at the Massachusetts General Hospital and in the private practice of one of us; they have never caused gastric disturbances. As an inexpensive preparation of digitalis which is of known strength, permanent and non-irritating to the stomach, these capsules deserve, we think, to be used very widely. They exhibit, of course, the disadvantage of slow and rather uncertain absorption, which we have found to be characteristic of the powdered leaf. The variation in physiological activity of the leaves from year to year is, moreover, so great that such capsules, to remain of uniform activity, will of necessity fluctuate considerably in size. The only alternative is to designate the physiological strength of the capsules on each package dispensed, a proceeding which would be apt to confuse the general practitioner.

In 1904 Cloetta¹¹ published his first paper on "Digalen" or "Digitoxinum soluble." Cloetta's preparation was welcomed by the medical profession as the first digitalis extract suitable for hypodermic application. It was soon found, however, that digalen is entirely unsuited for hypodermic and intramuscular use, since its application causes pain and is followed in a large number of cases by serious local reaction.¹² For

use by mouth, too, it offers no advantage over the galenical preparations. If it really contains digitoxin, it is open to all the objections which apply to the use of digitoxin in any form; as a matter of fact, Kiliani,¹³ who knows more about the chemistry of digitalis than any other living person, feels convinced that the active substance in digalen is not digitoxin, but impure digitalein, a body closely related to digitalin, but more soluble than the latter. In support of this view, Focke¹⁴ was able to show that digalen, which is advertised to contain .3 milligram of "soluble, amorphous digitoxin," is only one-fourth as strong as .3 milligram of "difficultly soluble" crystalline digitoxin, on the one hand, and a simple infusion of fresh macerated leaves (containing .25 milligram digitoxin), on the other. Focke,¹⁵ Worth Hale¹⁶ and the writers have found, moreover, that digalen is by no means constant in physiological action; various samples tested showing a material difference in strength. The clinical literature shows that digalen does not act any more promptly than do the ordinary galenical preparations made from good leaves¹⁷; it shows further that digalen exhibits a great tendency to cumulative action¹⁸; that the toxic dose is very near the therapeutic dose¹⁹; that the drug will cause nausea and vomiting to the same extent as the old preparations²⁰; in short, that the drug cannot in any way be considered a desirable addition to our stock of cardiac remedies. Worth Hale²¹ carried out a careful comparative research on digalen, digitoxin and digitalein, which is thoroughly convincing and which we would advise every investigator of heart remedies to read.

In a recent paper one of us²² reported on the clinical use of another new preparation of digitalis—namely, digipuratum. This preparation, which is a purified extract of digitalis, seems to approach more nearly to the ideal drug than any of its predecessors. Digipuratum is constant in action, it is permanent (a powder in our possession was found not to vary in strength from May, 1910 to May, 1911), it does not cause gastro-enteric disturbance (over 200 cases, Massachusetts General Hospital), it shows less tendency to produce cumulative intoxication than any of the other preparations of digitalis, and it is prompt and reliable in action. It has one great fault; it is very expensive compared to other preparations. But the method of manufacture and physiological assay of the drug is a most expensive one. We must be prepared in the future to pay well for preparations of this kind, which tend to make medicinal treatment more exact and more reliable, and which are helping to make clinical medicine a science.

The digitalis preparations discussed so far are all designed for internal use, and their action manifests itself at best in the course of from twenty-four to thirty-six hours. There are times when a heart stimulant, to save life, must act within a few hours, and it is just such a stimulant that chemists and pharmacologists have been trying for years to obtain. The first of this group to be of practical value was strophanthin, the

active principle of *strophanthus hispidus*. One of us introduced this drug into America four years ago,²³ and it has since been used to a certain extent, especially in hospitals. Strophanthin must be given intravenously, since its hypodermic application causes most intense pain and considerable local disturbance. If it is given intravenously with proper technique it acts as a wonderful cardiac stimulant, and its use is absolutely free from untoward actions of any kind. It may be safely said that if strophanthin fails to produce the desired effect, the heart of the patient is beyond digitalis—like stimulation. Strophanthin is also indicated in conditions of hydremia when absorption from the gastro-intestinal tract is reduced to a minimum on account of the water-logged state of the system. In such cases large amounts of digitalis given by mouth have no effect, the greater part of the drug is excreted unabsorbed and the accumulation of water in the system continues. Strophanthin given intravenously acts directly upon the heart, with the result that efficient diuresis occurs within twelve to twenty-four hours. The system which has been depleted of its excessive water-content is then in a condition readily to absorb digitalis preparations given by mouth. There is a class of cases which responds better to strophanthin action than to that of digitalis. In these cases strophanthin may be given intravenously for a period of days or for a week, and the results obtained in this way are incomparably better than either from digitalis or *strophanthus* by mouth. It may be said in general that *strophanthus* therapy by mouth is unsatisfactory; the reasons for this are not apparent, since the pure drug could be given, and the great uncertainty of *strophanthus* preparations avoided. It would seem that a considerable portion of the pure strophanthin given by mouth is either very quickly excreted before it can be absorbed or is destroyed before absorption.²⁴

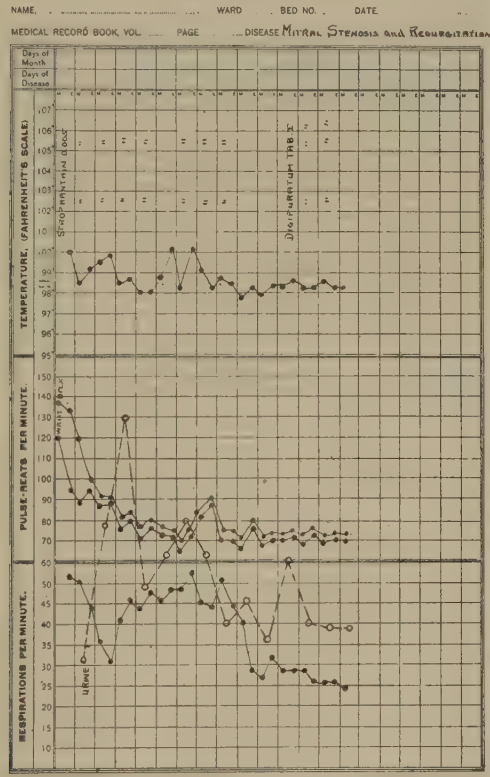
Case 1, the chart and brief history of which is reproduced in the text, offers a good example of the cases which are particularly suited to intravenous strophanthin therapy. As may be seen from the chart, this patient received on eight successive days half a milligram of strophanthin directly into the blood. The strophanthin diuresis and the effect on the radial pulse and apex beat are very striking.

Case 2 is illustrative of a class of cases, which, though hopeless from the first, require cardiac stimulation to keep them free from suffering to the end. In this case, digitalis by mouth had failed to give the patient relief and strophanthin was given intravenously as *ultimum refugium*. It is interesting to note the approach of radial and apex beat after the first two injections.

Intravenous medication is not popular with the general practitioner, and perhaps it is just as well that it should be so, since the injection of active substances directly into the blood is always a more serious procedure which is best confined to hospital and consultation practice. For general practice we need a preparation which may be given hypodermically or

intramuscularly. Until very recently there was no preparation suitable for this purpose, although many have been tried. A few months ago the manufacturers of digipuratum placed at our disposal a number of sealed and sterilized glass ampules, each of which contain .1 gm. (gr. $1\frac{1}{2}$) digipuratum dissolved in 1 c.c. of a solvent (probably 1 per cent.

CLINICAL CHART



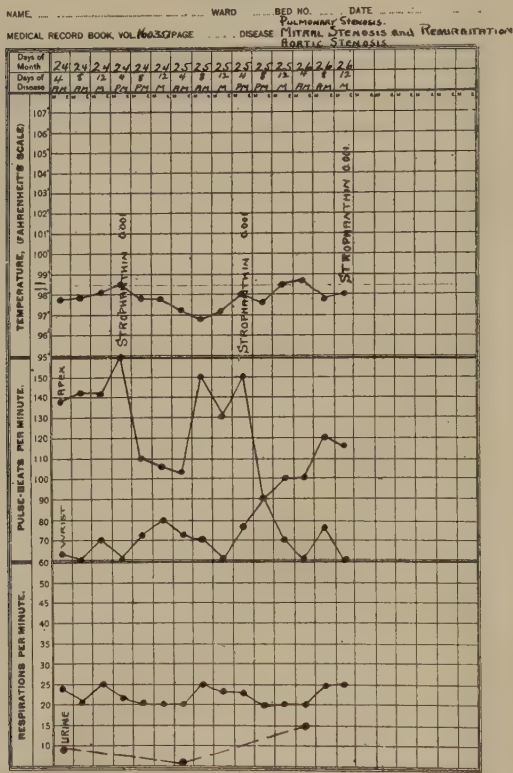
Case 1.—*Mitral stenosis and regurgitation.* Third break in compensation. Cyanosis, dyspnea, rapid very irregular heart. Marked discrepancy between apex and radial pulse-beats. Passive congestion of liver—no other edema. Marked relief from dyspnea after first dose of strophanthin, progressive improvement.

At discharge: Liver apparently normal, no dyspnea, heart almost regular, nearly all beats transmitted to wrist. Patient has been in hospital twice before for broken compensation—treated once with tincture digitalis, once with digipuratum; improvement with strophanthin more marked than with other drugs.

Na_2CO_3 solution). We have given this solution both intravenously and hypodermically with good results, but we were particularly interested in its applicability for hypodermic use, which is of such great importance to the general practice of medicine. The digipuratum solution did not produce pain or local inflammatory reaction in any of the cases. The

digitalis effect appeared in some cases within an hour, while in other cases a number of hours elapsed before this effect became evident. The injection of $1\frac{1}{2}$ grains (the contents of one ampule) was repeated twice the same day in some cases, but as a rule one or two injections in all were sufficient to prepare the way for medication by mouth. The

CLINICAL CHART



Case 2.—*Fibrous and verrucose endocarditis* of mitral, aortic and pulmonary valves with stenosis. Chronic adhesive pericarditis (slight). Cardiac hypertrophy and dilatation. Large pulsating liver, general anasarca, ascites, hydrothorax and hydropericardium.

First dose of strophanthin followed by marked temporary improvement in symptoms.

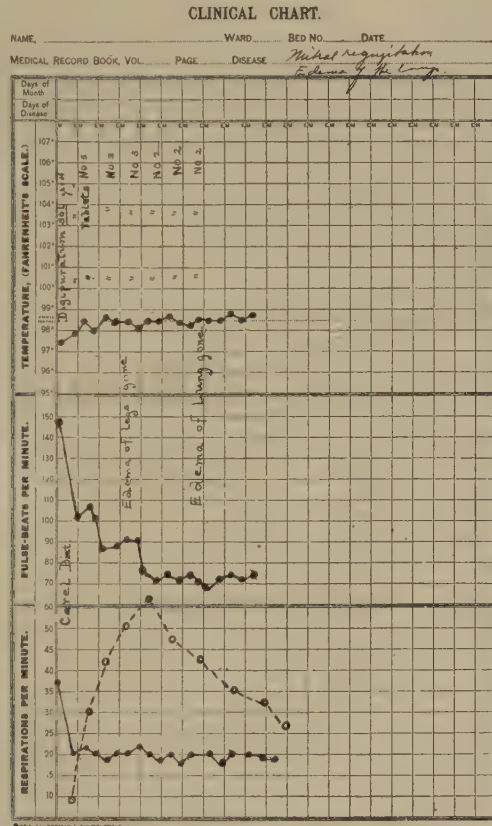
Second dose followed by same result, followed by alternating strong and weak heart-beat.

Third dose—no result until twenty-five minutes after administration. Patient suddenly became cyanotic, dyspneic, and died.

total number of cases injected to date is about twenty, and although the results in all these cases were very satisfactory, the number of cases treated in this manner is not sufficient to warrant final conclusions. The absence of local reaction in the cases treated, together with the well-established

reliability of digipuratum when it is given by mouth, promises well for the future of the drug.

Case 3.—When first seen at 4:30 a. m. this patient was in a condition of collapse, her respirations were very shallow and rapid, the pulse was 148 and hardly to be felt. For nearly a week the patient had been unable to sleep in bed; she had pronounced edema of the lungs, edema of the



Case 3.—*Mitral regurgitation.* Severe break in compensation. Edema of ankles, anasarca, edema of lungs. Very rapid pulse hardly to be felt. Extreme dyspnea; not able to lie down for several days, sleeplessness. After first injection great improvement in course of one hour. Pulse and respiration dropped. After second injection patient spent a good night in bed. Carel treatment. Steady improvement under digipuratum by mouth.

ankles, slight general anasarca. For several days she had passed only a few ounces of urine a day. The apex was heard in the fifth space $1\frac{1}{2}$ inches outside the nipple. The sounds were faint, there was a pronounced systolic murmur at the apex transmitted well into the axilla. On account of the puffiness of the skin it was difficult to find a vein in the arm without surgical preparation; it was therefore decided to give digipuratum solu-

The Carel diet, we think, is a very valuable therapeutic agent in the treatment of broken compensation. It consists simply in the strict limitation of food and drink to one quart of milk a day [5 glasses of good milk a day, beginning with 7 a. m. a glass (6 ounces) every 3 hours]. This diet is continued for five days and then solid food is gradually resumed while the total intake of liquids is kept at one quart. We have frequently seen mild breaks in compensation regain complete compensation with nothing but the Carel diet.

Case 4.—This patient was seen at the Boston Lying-in Hospital. It was a case of severe erysipelas of the breast occurring post-partum. The consultation occurred on the fifth day of the disease. The patient was in a serious state of collapse, and Dr. Belknap, the attending physician, had but little hope of her recovery. She was immediately given $1\frac{1}{2}$ grains digipuratum in solution, subcutaneously. The temperature began to fall within an hour after the injection and the patient's subjective condition improved markedly, while the pulse continued rapid for twenty-four hours, becoming, however, much more regular and improving in quality. At the end of the second day the pulse and temperature were almost down to normal, and the patient felt practically well. The respiration showed nothing remarkable, it was therefore not recorded. On the ninth day, after digipuratum had been omitted for two days, the pulse went up again. Under digipuratum by mouth, for several days, the temperature subsided completely, and the patient was discharged well.

To prevent the possibility of heart-block, care must be taken to obtain complete information concerning previous digitalis medication before giving strophanthin or digipuratum intravenously, or digipuratum subcutaneously. If digitalis has been taken the same day it will be wise to wait twenty-four hours before giving strophanthin intravenously, except in such cases where it must be given as a last resort. The subcutaneous application of digipuratum will be found, we think, a very safe method to produce rapid compensation; unless the pulse is suspiciously slow or dichrotic there will hardly be any danger in trying one subcutaneous injection of digipuratum solution, even if digitalis has been taken in moderate quantity the same day.

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ARTERIOSCLEROTIC CHANGES IN THE ABDOMINAL VESSELS.

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Through the descriptions of Ortner,¹ Muller,² Neusser,³ and Schnitzler,⁴ among others abroad, and Gilbride,⁵ and Akin,⁶ in this country, the clinical picture resulting from arteriosclerosis of the abdominal vessels has become fairly well defined. The picture has become sufficiently clear to justify its addition to the other members of the arteriosclerotic group, viz: the cardiac, the cerebral, the renal and the peripheral (intermittent claudication.) This paper is presented for the purpose of correlating the more important features of this type of arteriosclerosis and of adding a few new facts to its pathology and therapy.

Abdominal or splanchnic arteriosclerosis is equivalent to the other types of arteriosclerosis in its etiology and pathogenesis. The broadening concept that arteriosclerosis in general occurs as a result of abnormally increased functional demands (Kaufmann,⁷ Thoma, Albrecht, Marchand, Jores, the *Abnutzungskrankheit* of Romberg) applies with equal force to this form. Overeating, with chronic overloading of the stomach and intestines, is probably of special importance in the production of splanchnic vessel-change, in view of the direct strain on digestive function. Frankel and Hasenfeld,⁸ discuss the relationship of sedentary habits in corpulent individuals to the development of splanchnic sclerosis.

The clinical picture is many sided—at times resembling the gastrointestinal neuroses, at others simulating organic disease. The first evidence of the sclerotic process is seen most commonly in men over forty years of age, although vessel-changes frequently begin with puberty or earlier. Hirschfeld's,⁹ patient vomited blood from rupture of a sclerosed arteriole in the stomach at the age of eighteen. Gallard's,¹⁰ case was a young man of twenty-eight years: In an autopsy performed at the Augusta Hospital, Berlin, on a man thirty-two years of age, the abdominal aorta and the vessels of the lesser curvature of the stomach were markedly sclerosed.¹¹

The patients usually present marked weakness, loss in weight, and distaste for meat, suggesting carcinoma (Akin.) Inquiry reveals that this loss is due to lack of sufficient nourishment from fear of eating. Attacks of intense abdominal pain are often precipitated by food, particularly of the cabbage, pea, bean, etc., variety (Ortner),²¹ and the patient cuts down his rations with the hope of preventing future attacks.

Abdominal distension, belching and flatus are common complaints, often occurring paroxysmally, and at night. Examination may show localized abdominal meteorism with prominent intestinal loops, but without spasm or peristaltic waves. Elliott¹³ describes a similar paroxysmal flatulency occurring at night in arterial hypertension. The phenomena are probably identical and in both cases due to periodically increased blood pressure from vessel spasm (Pal).¹⁴

Probably the most characteristic of the clinical phenomena are the attacks of severe abdominal pain—the angina abdominis,—attacks closely resembling angina pectoris, except for their localization.* The patient localizes the pain in the epigastrium and about the umbilicus. It occurs usually from two to three hours after a heavy meal, is gripping and twisting in character, lasts usually from one or two minutes (Kuttner)¹⁵ to

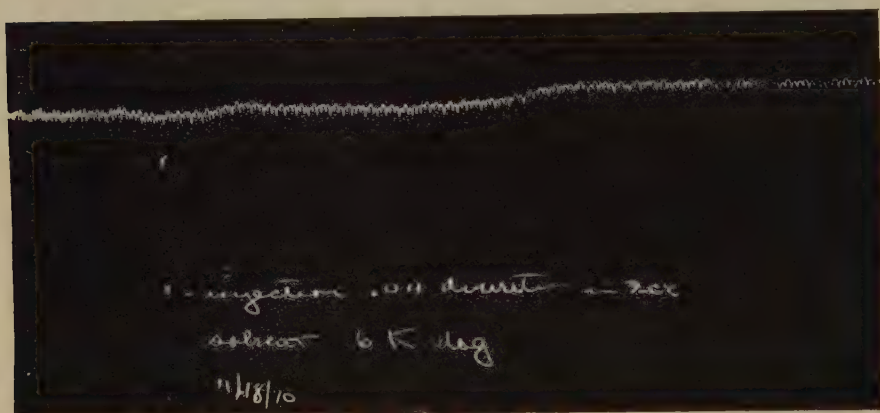


Figure 1.

The injection of 0.04 gm. diuretin in a 6 kg. dog causes a slight (10 mm.) rise of carotid blood-pressure recorded by a mercury manometer.

as many hours (Ortner), and is associated with distended abdomen, in contrast to the scaphoid abdomen in tabetic and lead crises (Pal), with dyspnea (and at times cyanosis), with obstipation, with anxiety and the fear of death. The agony of a patient during such a paroxysm may be intense. A woman in Neusser's wards, passing through such an attack, reminded one of the agony of the gastric crises, of intestinal obstruction, of kidney or gall-stone colic—with perhaps even increased intensity.

The cause of the angina has long been a source of dispute. Schnitzler and Markwald,¹⁶ draw the parallel to intermittent claudication and think the pain is due to ischemia following vessel spasm. Kaufmann and Pauli,¹⁷ and Ortner conclude that the pain is due to spasm of the vessel

*In this connection one remembers that the pain in true angina pectoris is often localized in the upper abdomen or even lower down. Cf. in particular. Neusser (Angina Pectoris).

itself from irritative changes in the intima. Buch¹⁸ obscures the question still further by the interesting observation of cases with extreme splanchnic vessel disease, but without symptoms. He suggests that there may be advanced endarteritic changes without involvement of adventitia, as Sternberg has described, in the extremities. This agrees with the views of Carriere,¹⁹ and Teissier,²⁰ that the tenderness is due to associated peri-arteritis.

The obstipation has likewise been the subject of some discussion. Pal¹⁴ showed experimentally in dogs, that peristalsis stopped in those segments of bowel whose blood supply had been interrupted. He explains clinically the obstipation as atony of bowel from anemia produced by vessel-spasm. Schlesinger²¹ saw recurrent ileus in two patients, which, through autopsy was shown to have been caused by sclerosis of the mesenteric

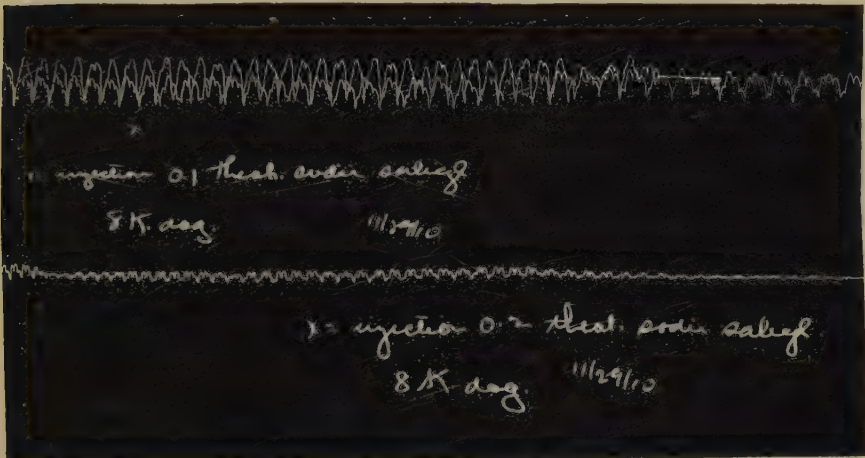


Figure 2.

The injection of 0.1 gm. theobromine sodium salicylate in an 8 kg. dog causes no change in the carotid blood-pressure (upper tracing). The injection of 0.2 gm. of the same drug 10 minutes later causes no change (lower tracing).

vessels. One case had undergone operation three times for obstruction without the cause being recognized.

Sudden profuse hematemesis simulating the hemorrhage of gastric ulcer, often with fatal outcome, is frequently the first and only evidence of abdominal vessel-disease. It occurs when the sclerosis has invaded the arterioles in the stomach and upper bowel submucosa. Gallard, in 1884, described the first fatal case of hematemesis on the basis of arteriosclerotic disease. His patient was a twenty-eight-year-old man who suffered with intense epigastralgia, and recurring bloody vomiting. Autopsy showed a small-erosion on the posterior wall of the stomach, the floor of which contained a grey thrombus in a small aneurysmatically dilated

vessel. Case nine, of the series to be reported, was a forty-three-year-old woman, who four years previously had undergone gastro-enterostomy for ulcer. Autopsy showed a small sclerotic ruptured vessel protruding through the healed ulcer floor.

There are a number of helpful physical findings which may serve as differential aids. Arterial tension is usually increased, the degree depending on the extent of vessel involvement. A patient now under observation at the Central Free Dispensary, Chicago, with advanced abdominal

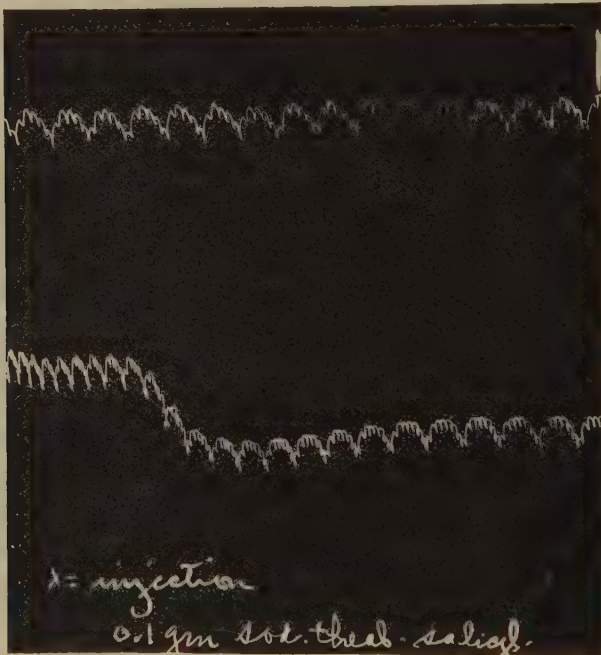


Figure 3.

The injection of 0.1 gm. sodium theobromine salicylate in a 4 kg. dog causes a slight fall in blood-pressure. (Lower tracing.)

arteriosclerosis, had a systolic blood-pressure of 196 mm. Hg. Left ventricular hypertrophy and accentuated aortic closure are present when the condition has persisted some time, and are directly related to chronic hypertension. During the attacks of angina the pressure is still further raised, due to vessel-spasm similar to the hypertensive crises in lead and tabes (Pal).

The relation of partial or complete obstruction of the splanchnic vessels to increased blood pressure has been recently studied experimentally. Longcope and McClintock,²² concluded that the rise in pressure, following clamping on the celiac axis and superior mesenteric artery, in dogs was due to mechanical blocking of circulation.

Marked abdominal pulsation and tenderness on pressure over the easily-palpable resistant aorta, are suggestive findings. Often one may hear a rough systolic murmur with the stethoscope over the course of the aorta.

Marked sclerosis in other vessels may be of valuable contributory evidence. In this regard, the recently published work of Fischer and Schlayer,²³ is particularly suggestive. Seventy-five per cent of the arteries diagnosed clinically by Romberg as sclerotic, failed to show microscopic change in intima or media. They concluded there must be "func-

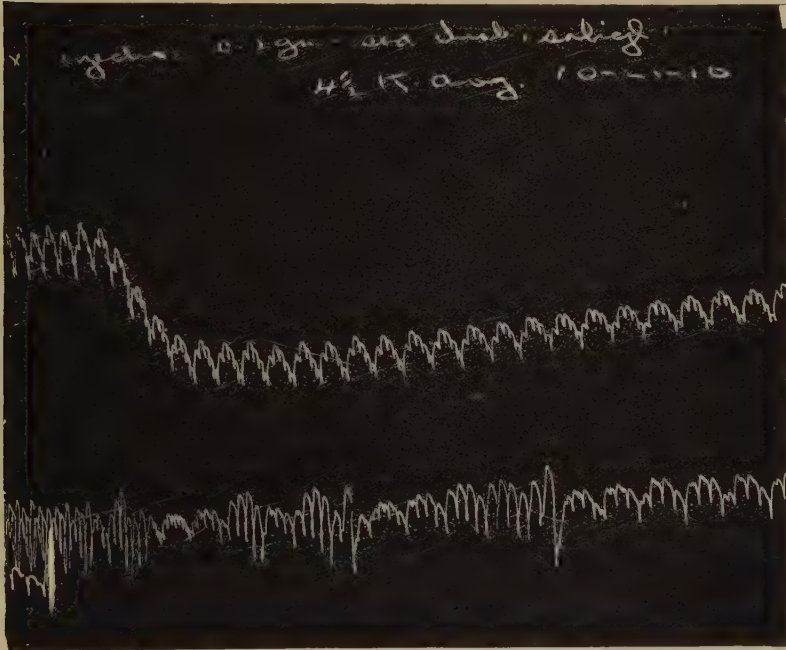


Figure 4.

The injection of 0.2 gm. sodium theobromine salicylate in a 4½ kg. dog causes a marked fall in the carotid blood-pressure recorded by a mercury manometer. (Upper tracing.)

tional thickening" in such vessels. The results show the need of conservatism in the diagnosis of sclerosis when thickening, resistance, and *tortuosity* are the only positive clinical findings.

The pathology of this report is based upon the results of the gross and microscopic study of 10 cases, carried out under the direction of Prof. Oestreich at the Augusta Hospital, Berlin. I shall give merely the conclusions reached from that study. The literature, technique employed, and findings in detail appeared in the *Deutsche Archiven fuer Klinische Medizin*, for August, 1909. Following the usual

autopsy, a careful macroscopic examination of the aorta and its larger branches was made.

Changes in the Stomach Vessels.—The 10 cases comprised five men and five women. In 6 cases under forty-three years of age, marked arteriosclerotic changes were found, the youngest being twenty-two years old. Two cases between 50 and 60 years of age showed no evidence of sclerosis. The changes in the stomach vessels were of the usual histological type found in sclerosis of other parts of the arterial tree, I found no aneurysmatically dilated arterioles described by other authors. In 3 cases a number of branches of the smaller vessels showed sclerosis, the remaining branches being entirely free. In some cases the vessels of the lesser curvature were more diseased; in others those of the pyloric

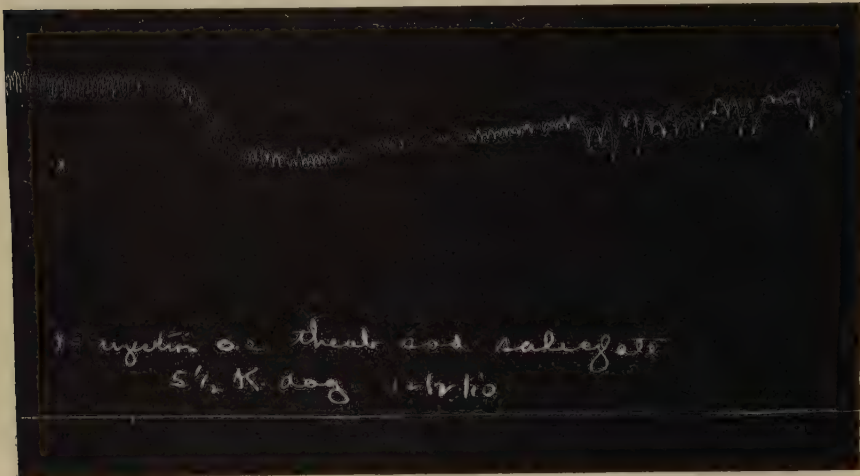


Figure 5.

Injection of 0.2 theobromine sodium salicylate with intact vagi. Compare with Figure 6.

or cardiac regions. No regular distribution could be determined, the vessels of the lesser curvature, the Art. Cor. vent. sup. dex. et sin. showing most frequent and extensive disease. The larger branches were more frequently involved than the smaller arterioles of the submucosa.

Changes in other vessels in relation to changes in stomach-vessels.—The conclusions may be summed up as follows:—

Marked irregularity in distribution of the arteriosclerotic process in different vessels. In spite of moderate sclerosis equally distributed throughout entire aorta, marked arteriosclerotic disease in coronary vessels in contrast to minimal change in celiac axis, and vice versa. One is not justified from the examination of any single vessel in estimating general arteriosclerosis. There may be no anatomico-pathological relationship between angina pectoris and angina abdominis in cases where

such a relationship seems to exist clinically. In this connection it is interesting to note a statement of Pal's, who describes hypertensive crises in perfectly normal vessels.

Changes in stomach vessels and their relation to pathological changes in stomach wall.—Minimal to moderate vessel scleroses cause probably no determinable changes in stomach coats. This is likewise true in other organs—brain, heart, kidney. Marked sclerosis, on the other hand, has important sequelæ in spite of the rich arterial anastomosis; in one case ulcer, in another adenoma. Lewin,²⁴ describes a similar benign adenoma in one of his cases. Arteriosclerotic disease in the stomach vessels occurred in the early years of life in this series, and suggests the relationship to gastric ulcer, which likewise appears comparatively early. The fact that the larger vessels were more diseased than the smaller, is another factor in favor of ulcer formation. In other organs anemic and

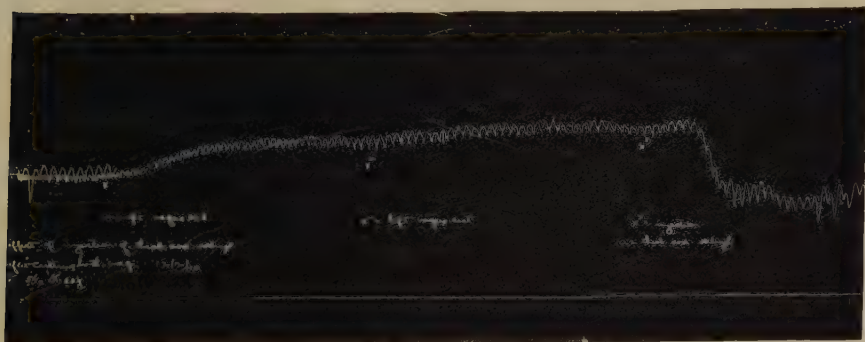


Figure 6.

Injection of 0.2 theobromine sodium salicylate after sectioning both vagi. Compare the marked fall in pressure with that obtained with intact vagi. (Figure 5.)

hemorrhagic infarcts follow closure of the larger vessels. A similar infarct or necrosis in the stomach would probably develop ulcer through digestion by stomach ferments.

Prophylactic measures for preventing the development of general arteriosclerosis are of course most essential. Until we understand more fully the metabolic processes concerned in arteriosclerotic disease, we must be content to give these in general terms. Reduction in excessive mental and physical work, in excessive food quantities, in tobacco, coffee, alcohol and other stimulants; avoidance as far as possible of fatigue, worry, anxiety and emotional excitement, moderation in exercise, sufficient sleep, sufficient warmth to the surface of the body with the prevention of chilling, regularity in bowel passage, out-of-door life in a warm equable southern climate of low altitude; these are among the controllable factors for the preservation of healthy arterial tissue.

When the vessels are definitely diseased similar measures are indicated. In addition, the iodides are usually given with supposed benefit. They probably do exert some direct influence on vessel-wall (Osler.)

I wish to speak particularly of the measures to be employed during the acute exacerbations of abdominal pain. Here active drug treatment must be instituted, together with complete rest in bed with warm applications to the abdomen. Osler,²⁵ recommends repeated large doses of nitroglycerine to lower blood pressure. Kreuzfuchs,²⁶ advises morphine. Kuttner, Pal, Neusser, Romberg,²⁸ Perutz,²⁹ Breuer,²⁷ Kaufman and Pauli, and Buch emphasize the value of the theobromine preparations, in particular diuretin (theobromine sodium salicylate).

The exact pharmacology of this action of diuretin is not clear. Plavec³⁰ (1904) from clinical observations on the diuretic action of theobromine concluded that it is a cardiac stimulant and a vaso-dilator, the resulting effect on blood pressure varying with the predominating action. Cohnstein, Thomas, Bock, Impens and Belan noted a fall of blood pressure following theobromine; Pfeffer, Geisler, Pawinski, Bordet, Tanszk and Solacoin noted a pressor effect.

Pal (1905) thought its activity as a vaso-dilator had not been demonstrated and quotes Neusser, that it may relieve the angina without influencing general arterial pressure. He suggests its point of action may be the sympathetic. Buch thought it neutralized the toxic effect of some hypothetical poison, which caused vascular contraction by irritation of the vasomotor center.

There seems to be no question that theobromine causes vascular dilatation as does caffeine.* In an endeavor to study its effects on blood-pressure, I have made some experimental injections in dogs. The work was done in the laboratory of the Michael Reese Hospital.

Diuretin (Knoll) and theobromine sodium salicylate (Merck) were used. They were dissolved in distilled water so that not more than 2 c. c. of total quantity of liquid was injected at any one time. The injections were made into the femoral vein of an anesthetized dog, the blood-pressure estimated from a cannula in the carotid artery connected with a mercury manometer and revolving smoked drum.

The results may be summarized as follows: Minute amounts of the drug (0.04 grm. in a 6 kg. dog) produce a very slight pressor effect (Fig. 1.) Somewhat larger dosage (0.1 and 0.2 grm. in an 8 kg. dog) produces apparently little if any effect (Fig. 2.) A very slight increase over an amount which produces no effect on blood-pressure, is sufficient to produce a distinct depressor effect. Fig. 3 (0.1 grm. theobromine sodium salicylate in a 4½ kg. dog.) Fig. 4 (0.2 grm. in a 4½ kg. dog.) Larger amounts produced a correspondingly greater depression. The average fall of pressure produced by increasing amounts has been tabulated in the following table:—

*Personal communication from Dr. G. N. Stewart, of Cleveland.

Grms. Sodium Theobromine Salicylate per kw. of animal.	Effect on blood-pressure expressed in mm. of Hg.	
	Rise.	Fall.
.0066	10mm.	0
.0125	0	0
.022	0	22mm.
.040	0	30mm.
.062	0	36mm.
.066	0	42mm.
.125	0	65mm.

The effect on the heart was not constant. Small amounts caused a moderate slowing while the large doses causing marked depression of blood pressure were usually accompanied by an acceleration of heart beat, probably an attempt to overcome the fall of pressure. That the depressor effect is due to a peripheral action was demonstrated by comparing the effect of injection before and after section of both vagi. Fig. 5 shows a fall of 24 mm. as a result of the injection of 0.2 gm.

Fig. 6 shows a fall of 62 mm. following the injection of an equal amount, both vagi having been sectioned just before injection.

While these results are not conclusive, they suggest strongly that the relief given by theobromine in abdominal angina is due to splanchnic dilatation, the area of greatest peripheral vaso-dilation. The effect on blood pressure seems to be of secondary importance, depending on the relative balance between cardiac activity and peripheral vasomotor tone.

SUMMARY.

1. The clinical picture of abdominal arteriosclerosis is characterized by abdominal tenderness and distension, (without peristalsis), by severe paroxysmal abdominal pain, obstipation, hypertension and at times sudden profuse hematemesis.

2. The pathology of abdominal arteriosclerosis is similar to that of the peripheral vessel sclerosis; the larger branches of the vessels of the lesser curvature of the stomach are most frequently involved; advanced sclerosis of the gastric vessels seems to have a rather direct relationship to the production of gastric ulcer.

3. Intravenous injections of moderate amounts of theobromine sodium salicylate (diuretin) in dogs cause a fall in the carotid blood-pressure, apparently from splanchnic vaso-dilation. This may explain the relief obtained clinically in angina abdominis following administration of the drug.

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The more or less unconscious estimation of the blood-pressure by means of palpation of the radial artery is probably almost as old as the art of medicine itself. Our predecessors, with their highly trained sense of touch, must often have drawn just conclusions as regards the degree of tension of the arteries they palpated, although they were unable to formulate their observations as precisely as we now can. Indeed, some eminent clinicians even to-day maintain that they can estimate the blood-pressure at least as accurately by means of the palpation of some of the larger arteries as by the use of apparatus. Nevertheless, the fact remains that our knowledge of the behavior and significance of blood-pressure in health and disease has been drawn from the use of modern clinical instruments of precision.

In discussing this subject, the difference between the so-called systolic and diastolic pressures must always be kept in mind. With each beat

of the heart, a certain amount of blood is thrown out into the arteries. These, however, being highly elastic dilate to receive this blood and empty themselves only gradually through the capillaries into the veins. Thus the next beat of the heart finds the arteries still full of blood and this blood still under a considerable pressure, owing to the elastic tendency of the arteries to contract. The additional blood thrown into the arteries causes a renewed rise in pressure of their contents, so that the blood in them is alternately placed under a higher and a somewhat lower pressure, the latter, however, never even approaching zero. The former has been called the systolic or maximum pressure, the latter the diastolic or minimum pressure.

TECHNIQUE.

A great variety of instruments has been devised for the purpose of registering the blood-pressure, all of which are fundamentally based

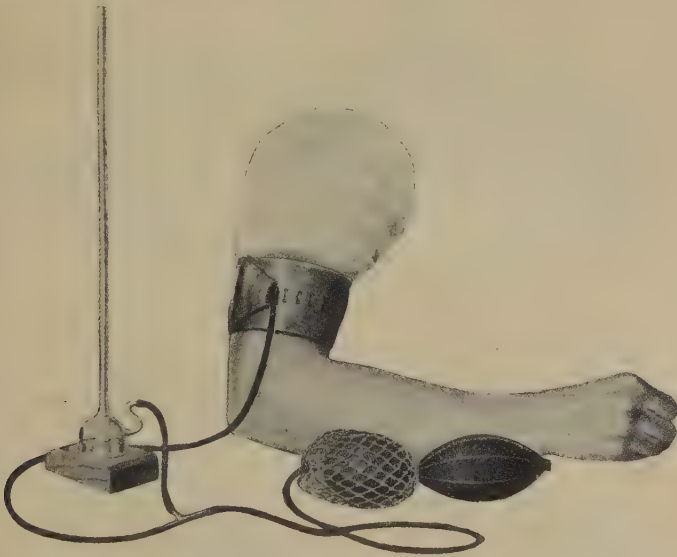


Fig. 1.—Cooke's modification of the Riva Rocci Sphygmomanometer.

upon two original types. The first, that of v. Basch, modified later by Potain, consists of a rubber bulb, whose lumen is connected with a mercury manometer. The bulb is placed over an artery and sufficient pressure exerted to cause the disappearance of the pulse, this pressure being registered in the manometer. The disadvantages of the apparatus are many, the fatal one being that any lateral pressure against the tissues, a matter hardly to be avoided, is registered as well as the pressure directly exerted upon the artery. The other method, upon which most modern instruments are based, dates from the communication of Riva Rocci in 1896. In this a rubber bag is made to encircle the arm and is inflated by a rubber bulb, the pressure in the arm-band being registered in a manometer. The amount of pressure required just to cause a disappearance of the radial pulse registers the maximum or systolic blood-pressure. The artery is equally compressed from all sides against the humerus, thus doing away with the chief fault of the earlier methods. Riva

Rocci, as more recent work has shown, used too narrow an arm-band. This, when inflated, produced a furrow in the arm, so that some of the pressure registered in the manometer was exerted upwards and downwards against the tissues and not upon the artery. Hence, all of the modern sphygmomanometers use an arm-band 10-12 cm. wide, in which this source of error is reduced to a minimum. They differ chiefly in the construction of the manometer. A brief description of some of those most commonly used may prove of interest to our readers.

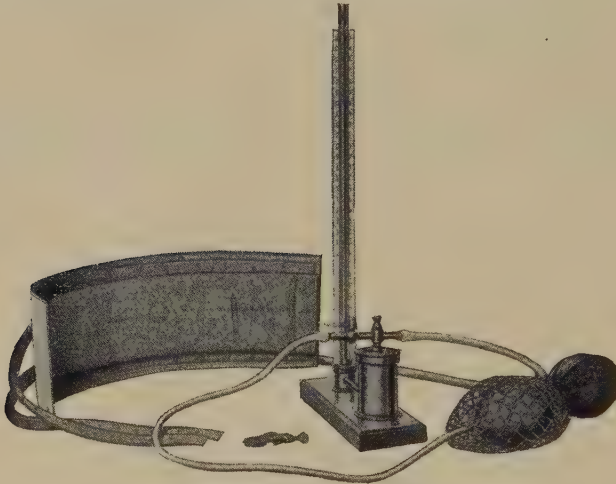


Fig. 2.—Stanton's Sphygmomanometer.

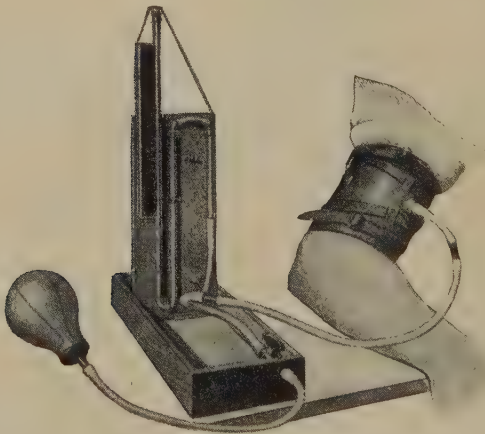


Fig. 3.—Janeway's Sphygmomanometer.

Riva Rocci Sphygmomanometer (Fig. 1).—The instrument that most nearly approaches the original apparatus of Riva Rocci is Cooke's modification. A long jointed glass tube, graduated in millimeters arises from a cistern of mercury, which is connected on the one hand with a cloth covered rubber arm-band and on the other with a double cautey bulb inflator. The instrument is fragile and not readily portable.

Stanton's Sphygmomanometer (Fig. 2) avoids these faults by the use of a metal cistern and more rigid joints. The rubber arm-band is surrounded by a canvas cuff. The instrument is easily portable, but a little troublesome to set up and the mercury is readily spilt by the inexperienced user.

Janevay's Sphygmomanometer (Fig. 3) employs the U-tube mercury manometer, with the longer arm jointed, and a Politzer bulb as inflator. It is readily portable and very convenient to use but is rather fragile and in it, too, the mercury is easily spilt.

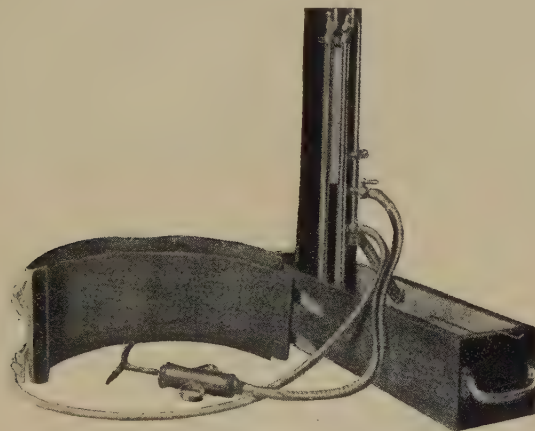


Fig. 4.—Faught's Sphygmomanometer.

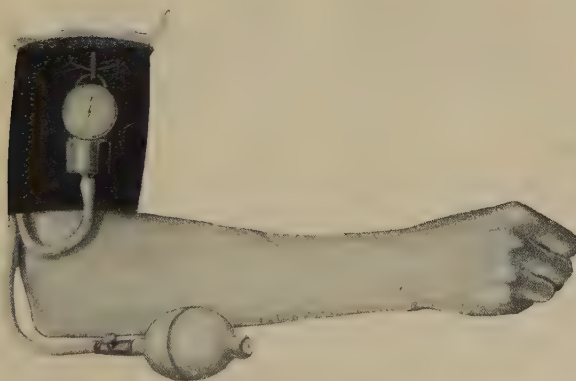


Fig. 5.—Roger's (Tycos) Sphygmomanometer.

Faught's Sphygmomanometer (Fig. 4) is perhaps the most convenient of those using the mercury manometer. Each arm of the U-tube, which is not jointed, but is mounted solidly against the lid of a box, is provided with a stop-cock which is closed before the instrument is put away and thus avoids all danger of spilling the mercury. The most recent models have a metallic pump which is in every way superior to the rubber bulb inflators. The instrument packs into a box some fourteen inches long in which it can readily be carried about.

Roger's Sphygmomanometer (Fig. 5) is more conveniently portable

than any of the above. The mercury manometer is replaced by a metallic spring with a dial, the arm-band is held in place by a cloth cuff which is simply wrapped about the arm and the inflator is of the atomizer-bulb variety. The whole can readily be carried in the coat pocket. The dial manometer is however neither so delicate nor so permanent as those employing mercury.

Erlanger's Sphygmomanometer (Fig. 6) has the great advantage of affording graphic records. By means of an ingenious device, the impulse of the brachial artery against the inflated rubber arm-band is recorded on the smoked surface of a kymographion drum. When the arm-band is inflated so as entirely to occlude the artery, no pulsation is registered. As the pressure is allowed to fall, the appearance of distinct pulsations marks the systolic pressure. The pulsations grow larger as the pressure falls until the point of diastole pressure is reached; whereupon they rapidly decline in amplitude. The disadvantages of the apparatus, besides its bulk, lie in the fact that the mercury column and the pulse tracing must be watched simultaneously, not always an easy matter, and that the

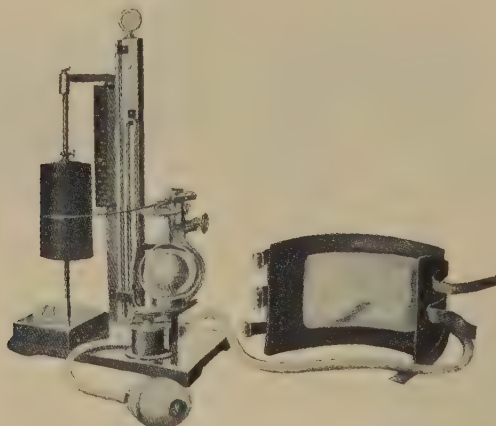


Fig. 6.—Ehrlanger's Sphygmomanometer.

point of systolic pressure is not always distinctly marked. For the purpose of recording the diastolic pressure, however, the apparatus is the best at our disposal.

Von Recklinghausen's Tonometer (Fig. 7) is extensively used for accurate blood-pressure measurements, especially in Germany. It consists of an extremely delicate spring manometer, a wide cuff not unlike those described above and a long, metallic air-pump. While bulky, it is portable. Its chief disadvantage is its relatively high price.

Hill's Sphygmometer (Fig. 8) has the usual arm-band and inflating bulb and an ingenious portable mercury manometer. It consists of a single tube, the lower end of which is sealed into a small reservoir, as is shown in the enlarged figure of this part of the instrument. The armlet tube is attached to the end of the glass tube, which is also sealed into the reservoir, and opens into the upper part by a capillary opening. A small quantity of mercury is introduced into the reservoir. When the pressure is increased, air is forced into the reservoir and the mercury is driven up the manometer, registering the pressure on a millimeter scale.

When in use, the manometer is fastened to the wooden thermometer case, in which it is carried, by a rubber ring; a simple little brass foot is screwed on the end of the case and supports it in the vertical position. The brass foot folds up and goes into the case beside the thermometer. Owing to the capillary openings the mercury does not spill. The wooden case containing the manometer may be thrown into a satchel with the arm-band and bulb, and thus carried conveniently.

Among the instruments less frequently used a few deserve still to be mentioned.

Sahlb's Sphygmobolometer is a complex apparatus by means of which not only the blood-pressure but the energy of the pulse may be measured. The complexity of the apparatus and the skill required for its manipulation render it as yet suitable only for purposes of research.

The Sphygmo-oscillometer was devised by Panchon, a Parisian physiologist. It consists of a pump, an arm-band and a manometer con-

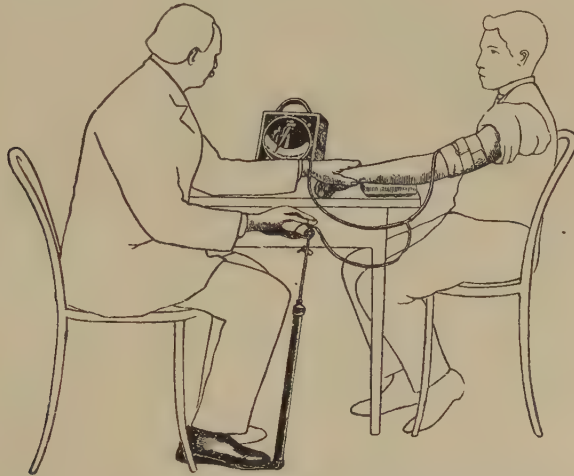


Fig. 7.—Von Recklinghausen's Sphygmomanometer.

sisting of a rigid metal box containing a delicate aneroid barometer. The amplitude of the oscillations of the latter renders the estimation of the diastolic pressure particularly accurate.

Gaertner's Tonometer, though very portable and compact, has practically been abandoned by clinicians. A small hollow rubber ring, connected with a pump on the one hand and with a manometer on the other, is slipped over the finger which is then made anemic by means of a rubber band. The latter is removed and the pressure that will just permit the return of the blood to the finger-tip is recorded. The apparatus permits only of the determination of the systolic pressure and even so is subject to a variety of sources of error.

METHODS OF ESTIMATING BLOOD-PRESSURE.

Palpatory.—The older methods of estimating blood-pressure all depend upon the palpation of the radial artery, while pressure is exerted higher up, usually by means of an elastic bag upon the brachial. The arm-band

is first inflated until the radial pulse has entirely disappeared. Then with the eyes upon the manometer and a finger upon the radial, the observer allows the pressure to fall, until the radial pulse reappears. This point marks the maximal or systolic pressure. As the pressure in arm-band and manometer is allowed to fall still further, the radial pulse becomes stronger. A point of maximum pulsation is reached, after which, if the pressure continues to fall, the pulse again becomes smaller. This point of maximal radial pulsation marks the minimal or diastolic pressure. A little training of the sense of touch is required for the determination of the maximal blood-pressure, beginners usually obtaining results somewhat too low. A much higher degree of *tactus eruditus* is

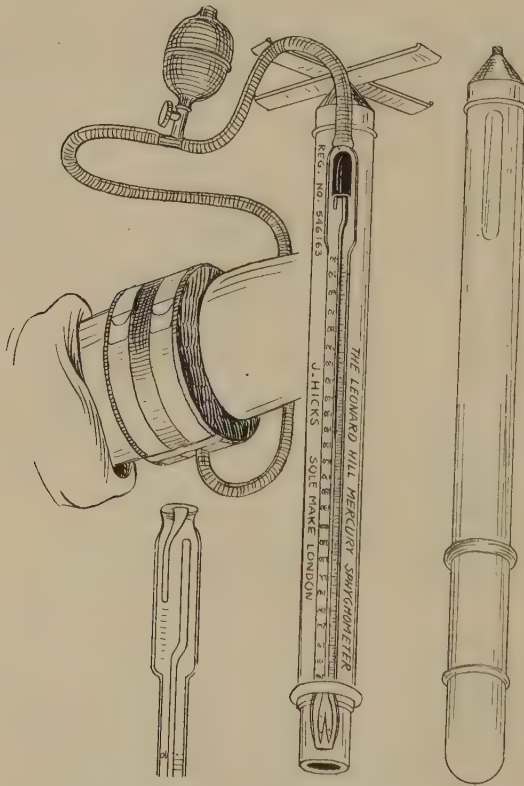


Fig. 8.—Hill's Sphygmometer.

necessary for the palpatory determination of the minimal or diastolic pressure. The difference between the strength of the radial pulse 10 mm. above and below the point of maximal intensity is by no means always great, and different observers, especially if relatively unskilled, will by no means always agree in their estimates. The method becomes somewhat more satisfactory if, as suggested by Hirschfelder, "the artery is palpated with the ball of the finger instead of the finger-tips, while the finger-tips rest against the radius." Repeated determinations are necessary.

The chief recent exponent of this method, though in a modified form,

is Ehret. He has found that, as the pressure in the arm-band is steadily raised, a point is reached at which the pulsation in the cubital artery, at the bend of the elbow, suddenly becomes stronger; so much so that the adjoining tissues are shaken with each pulse. This point marks the diastolic pressure, as Ehret was able to show by comparison with other methods of recognized validity. He considers it the simplest and most accurate method of determining the diastolic pressure. Our own experience with the method has not been so favorable. Cases are not infrequent in which the change in amplitude of the pulse at the point of diastolic pressure is by no means so striking as Ehret's description would lead one to suppose. For routine use we consider it distinctly inferior to the equally simple auscultatory method.

Oscillatory.—If, after raising the pressure in the arm-band high enough to occlude the brachial artery and then slowly allowing the pressure to fall, one watches the mercury manometer, one is usually able to see very faint oscillations of the top of the mercury column. These are due to the brachial pulse impinging from above upon the occluding air-bag. As the pressure in the bag falls a point is reached at which these tiny oscillations suddenly become more marked: this is due to the passage beneath the arm-band of the first pulsations and marks the point of maximum pressure. As the pressure in the arm-band continues to fall, the oscillations of the mercury become more marked and reach their maximum at the point of diastolic or minimal pressure. Thereupon they again decrease rapidly in amplitude. In the more delicate sphygmomanometers of Ehrlanger, v. Recklinghausen and Pachon, these differences are more marked and more readily recognized than in the simple instruments of Janeway, Stanton and Faught; in the instruments of Ehrlanger and Uskoff the fact that the pulsations are registered graphically reduces the personal factor to a minimum. There can be no doubt that, in these better instruments, this method represents the best means for accurately determining the minimal pressure. The point of maximal pressure cannot always be so accurately made out by this method.

Auscultatory.—For routine clinical work, the auscultatory method of Korotkow is at once the most convenient and the most accurate. If the arm-band is inflated to a point above the maximal pressure and the bell of a stethoscope is placed over the cubital artery in the bend of the elbow, nothing is heard. As the pressure is now slowly allowed to fall, a knocking sound, synchronous with the heart-beat, is heard over the artery as soon as the maximal pressure is reached. This sound is evidently due to the sudden distension of the walls of the empty artery by the first jets of blood that pass below the occluding arm-band. As the pressure falls, this knocking sound grows louder, is then often replaced by a murmur, which again gives place to a knocking sound similar to the first. This last sound then suddenly diminishes in intensity and, after a further fall of a centimeter or so, ceases entirely. Miss Allen and Mr. Engle, in the study of the blood-pressures of thirty-five patients in the Johns Hopkins Hospital, compared this method with the results obtained with the Ehrlanger instrument. They found that the minimal pressure corresponded very accurately with the entire disappearance of all sounds, a view which is shared by most of those who have studied this question. A number of observers, among them Fischer, Lang and Manswetowa and Hoover, hold that the point of diastolic pressure is to be found at the instant when the second knocking sound suddenly diminishes in intensity. Our own observations lead us to con-

sider this latter view the correct one, but the entire subject clearly requires further study.

We may say then that the palpatory method is useful chiefly for the determination of the maximal blood-pressure, and the oscillatory method for the determination of the minimal blood-pressure. The auscultatory method, on the other hand, is equally useful for both.

Goodman and Howell have made a careful study of the sounds heard over the cubital artery during the auscultatory determination of blood-pressure, and have arrived at some interesting conclusions. Following Ettinger they distinguished five phases: first, "a loud, clear-cut snapping tone (the first phase), which is followed by a second phase, consisting of a succession of murmurs; the third phase begins with the disappearance of the murmurs and the appearance of a tone resembling in a certain degree that of the first phase, but less well marked, which soon becomes less clear in quality (dull) the fourth phase, and is followed by the disappearance of all sounds, the fifth phase." They consider close observation of the succession of these sounds in a given patient valuable not only for the determination of systolic and diastolic blood-pressure, but also, in certain cases, for the diagnosis of the nature and extent of the cardiac lesion. Thus in aortic insufficiency there is no fifth phase, the persistence of the snapping tone being almost pathognomonic. In arteriosclerosis with cardiac hypertrophy, the second and third phases are prolonged (high pulse pressure); where there is no such prolongation, in this condition, the heart has become relatively incompetent. When failure of compensation sets in, the second phase is the first to suffer, not only by a decrease in the range through which the murmur is heard, but also by an impairment of its intensity. The third phase is the next to be affected by an encroachment of the fourth phase, which is correspondingly lengthened, an indication of severe incompetence. Organic and functional cardiac derangements may be distinguished by the occurrence of variations in the intensity of successive murmurs and tones, or even by an alternation in the order of their occurrence: features characteristic of functional rather than organic cardiac derangements. Tornai reported similar observations, somewhat over a year ago. He believes that this method affords us the best means of estimating the functional capacity of the heart.

It is generally assumed that, at the point of maximal or systolic blood-pressure, when the constricting arm-band just prevents the passage of the pulse, the artery is entirely occluded. Benczur, after determining the maximal pressure simultaneously, in the same arm, with a Riva Rocci arm-band and a Gaertner tonometer, concludes that this is by no means the case. The so-called maximal pressure, he maintains, suffices to prevent the passage of the pulse, just as do the capillaries, but leaves the artery still patent. A considerably higher pressure is required completely to occlude the artery. From a comparison of these two pressures, he derives conclusions, in cases of heart disease, as to the degree of cardiac compensation. Benczur's observations are interesting and important, if true, but require confirmation.

In this connection the interesting observations of Hoover deserve mention. While not decrying the value of instrumental determination of the blood-pressure, he calls attention to the fact that the older methods of direct palpation of the artery do not deserve the neglect into which they have fallen. While it is true, that palpation of the radial gives results that are untrustworthy, this is merely because the radial is too

small a vessel. If a large superficial artery, such as the femoral artery, be palpated a trustworthy impression of the lateral pressure in the abdominal artery is readily obtained. This simple little manipulation deserves a place in every routine physical examination. With a little practice, Hoover maintains, the clinician should be able so to estimate the arterial pressure within 10-20 mm.

BLOOD-PRESSURE IN HEALTH.

In general it may be said that the average blood-pressure increases with advancing years. The limits in normal individuals at rest are usually taken as systolic, 110 to 135 mm.; diastolic, 60 to 90 mm.; pulse pressure, 30 to 45 mm. At all ages, 160 mm., or over must be regarded as pathological; in younger people, somewhat lower pressures may be so considered.

Woley has measured the arterial pressure in 1,000 healthy persons varying in age from fifteen to sixty-five. Five physicians shared in this task and each record was checked by the use of two different instruments. The "average high" pressure was obtained by averaging the highest 15 per cent. of records; the "average low" pressure by a similar treatment of the lowest 15 per cent.

"With this explanation, the results reached after a study of 1,000 blood-pressures are as follows:—

The average blood-pressure for males at all ages was 127.5 mm.

The average blood-pressure, for females, at all ages, was 120 mm.

By taking them in groups, first, from ages 15 to 30, the average blood-pressure was 122 mm. An average high blood-pressure of 141 mm., and an average low of 103 mm.

Second, those from 30 to 40 years of age gave an average blood-pressure of 127 mm. An average high of 143 mm., and an average low of 107 mm.

Third, those from 40 to 50 years of age gave an average blood-pressure of 130 mm., an average high of 146 mm., and an average low of 113 mm.

Fourth, those from 50 to 60 years of age gave an average blood-pressure of 132 mm., an average high of 149 mm., an average low of 115 mm."

It will be seen that "there is a gradual rise in the blood-pressure as the years advance. There is also a corresponding rise in the high and low averages. It can be readily seen that between 50 and 60 years of age a man giving a blood-pressure of 145 mm. could undoubtedly be accepted without further question, while a man under 30 years of age giving the same blood-pressure would present a case for further study and investigation.

In regard to women, it will be noticed that the average blood-pressure at all ages was 120 mm., about 8 mm. below the average in males at all ages. There is practically the same ratio of increase in blood-pressure in women as in men at the same age. In women it averages 8 points below the men."

Seiler has investigated the normal pressures in children and comes to the following conclusions. At the age of two to three years the systolic pressure is 80 mm., from which it rises gradually till at sixteen to seventeen it reaches 110 to 120 mm. In children of the same age, the pressure varies also with height and body weight. Sex makes no difference.

One important source of error, inherent in all blood-pressure determinations, must never be forgotten. As has long been known, and as

Schrumpf and Zabel have recently shown in detail, various psychic influences may cause a temporary rise of blood-pressure, sometimes of a very considerable degree. Thus the pain caused by the constricting arm-band, fear of the unusual procedure or of an unfavorable verdict from the physician, impatience at the undue duration of the test or even a disagreeable thought that may be occupying the patient's mind, may cause a temporary increase in blood-pressure. This increase will be most marked in neurotic individuals and may equally affect those with and those without a permanent hypertension. A lowering of the blood-pressure does not seem to result from psychic influences. If then, we find the blood-pressure normal or low, the psychic element may be neglected. If it is high, care must be taken to exclude this source of error. Of a number of differing observations on the same patient, the lowest ones will most nearly represent the true value. This psychic disturbance can best be eliminated by establishing a proper understanding between patient and physician, and by completing the test with as little delay as possible.

HYPERTENSION.

While a number of practitioners, who are making frequent use of the sphygmomanometer for the purpose of detecting the presence of hypertension, is ever increasing, the prevalent notions regarding the real significance of this phenomenon are very vague. There is a widespread belief that hypertension is in itself a disease, towards the relief of which, medical and other therapeutic measures must be directed. This is as much an error as it would be to consider icterus or albuminuria diseases in themselves. Hypertension is merely one manifestation of some underlying pathological condition, the recognition of which is essential for proper diagnosis and rational therapeutics. Another erroneous notion is the confusion between arteriosclerosis and hypertension. Recent work along this line has shown that abnormally high blood-pressure occurs in barely half of the cases of outspoken arteriosclerosis of the peripheral vessels, and that even in these cases it may be due to some other cause. Where the artery to be tested is very much thickened, the resistance of the arterial coat itself to compression must be taken into consideration, in estimating the significance of an apparently increased blood-pressure. This source of error may be detected or even eliminated by taking the blood-pressure in the other arm or in either leg. Arteriosclerosis never affects all the arteries alike, so that in some of them the apparent blood-pressure will be nearer the real figure than in others. In such a series of determinations, the lowest pressures found will be nearest the true value. Moreover, it is astonishing how often we find pressures normal or subnormal in patients with greatly thickened or even calcareous arteries.

The conditions responsible for the occurrence of hypertension may, following Rudolf, be conveniently grouped into five divisions:—

1. Toxines that directly raise blood-pressure and at the same time have an injurious effect upon the arterial wall. Such are nicotine and the products of proteid decomposition in the intestine;
2. Toxines that directly raise blood-pressure without injuring the arterial wall;
3. Local disturbances of the circulation in the brain, kidneys or elsewhere, that lead to a compensatory rise in blood-pressure;

4. High-grade neurasthenia; and

5. Arteriosclerosis of the aorta and the splanchnic vessels.

As regards the first group, its significance for the therapeutics of the condition is evident and will be considered more in detail later. Where the action of these toxins is long continued, the persistent hypertension caused by them will eventually lead to general arterio-capillary sclerosis. The patient then presents the picture of hardened arteries with hypertension, and the temptation is great to consider the latter as due to the former, whereas the reverse is actually the case.

In connection with the second group, the toxemias of pregnancy especially require consideration, one of the earliest and most constant signs of these conditions being a rise in blood-pressure. For the last five years, Starling has made it a rule to take the blood-pressure as often as possible of every pregnant woman under his care, especially during the last two months of pregnancy. In spite of the conclusions arrived at by Vogeler and other writers, Starling is convinced that, during the whole period of normal pregnancy, the blood-pressure is normal—that is, from 110 to 120 mm. Hg. Any rise of blood-pressure above 125 mm. would make him suspect that the pregnancy was not quite normal and would put him on the lookout for some degree of toxemia.

Hirst has obtained similar results, the pressure in 100 normally pregnant women averaging 118 mm. Hg. during the first seven and a half months and rising to 124 mm. towards the end of pregnancy. In women showing evidence of toxemia, however, the picture changes. The blood-pressure, in thirty-nine women with eclampsia and eighteen who did not have eclampsia, but had marked albuminuria at the time the first examination was made, was at its lowest 142 mm. Hg. The highest blood-pressure recorded in a woman without eclampsia was 192 mm.; the highest in an eclamptic was over 320 mm., the mercury running out of the top of the tube before a sufficient pressure was obtained to shut off the pulse.

Green concludes from his studies of puerperal toxemia that "eclampsia is a toxic condition dependent primarily on the development of the fetus, manifesting itself by general and renal signs. This may be of varying grades, impending or mild, acute or severe, and fulminating or fatal. Each grade presents a definite clinical picture and is associated, the first with a moderate, the second with a marked, the third with an extreme increase of blood-pressure. In the first two the symptoms disappear and the blood-pressure falls after delivery. In the last the blood-pressure rises and the disease progresses to a rapidly fatal termination. The blood-pressure seems definitely related to the type of case, and its observation should be of value in prognosis and treatment."

The third group includes those cases of increased intracranial pressure, cerebral arteriosclerosis, beginning interstitial nephritis and the like in which an increased blood-pressure is indispensable for the adequate supply of blood to these vital organs. Here an attempt at medicinal reduction of the blood-pressure might have serious results if, fortunately, it did not almost always fail of the desired effect. The mechanism by which hypertension is maintained in these conditions is still obscure. The experiments of Alwens are of interest in this connection. He enclosed, one kidney of a cat in an oncometer which communicated, on the one hand, with a pump and, on the other, with a mercury manometer. As soon as pressure was exerted upon the enclosed kidney, the animal's blood-pressure rose promptly, to fall again when the pressure was re-

leased. This phenomenon occurred even when all of the kidney's nervous connections were severed, so that it must, at least in part, have been purely mechanical. The rise observed was, however, far less than that observed in human beings with interstitial nephritis, so that in this condition a variety of factors is probably responsible for the hypertension.

The hypertension of neurasthenics has already been discussed. It is very variable and dependent upon psychic influences. In any concrete case the true significance of an observed hypertension can never be determined unless this source of error has been eliminated.

Sclerosis of the aorta and of the splanchnic vessels may, it is true, lead to a compensatory hypertension on account of its interference with the function of the kidneys and of other vital organs. Ordinarily, however, arteriosclerosis is a result rather than a cause of hypertension. A striking illustration of this fact is to be found in the result of repeated injections of adrenalin into rabbits. The persistent hypertension that results from these injections is soon followed by generalized arteriosclerosis. Clifford Allbut classifies cases of arteriosclerosis from the etiological point of view as follows:—

1. Arteriosclerosis resulting from high blood-pressure;
2. Infectious and toxic cases; and
3. A senile group.

In the second and especially in the third group, hypertension is often absent or is at least a late complication. Where the arteries of the extremities are greatly thickened, a certain allowance must be made for this factor, in estimating the true blood-pressure (according to Herringham, 3-34 mm. Hg.), and in such cases a real hypertension cannot be assumed unless a hypertrophy of the left ventricle can be demonstrated.

Besides the persistent hypertension discussed above, a number of cases of paroxysmal increase in arterial pressure have been recently reported. Thus Barker describes a case of tabes dorsalis in a woman, in which the blood-pressure rose during a gastric crisis to 220 mm., the diastolic pressure being 190 mm. The crisis lasted seven days, the blood-pressure remaining high during the entire period, except when temporarily depressed by amyl nitrite. With the cessation of the crisis, the pressure dropped to 120 mm., and there remained. Petren has observed 2 cases of aneurysm of the aorta, in which cardiac asthma seemed to be preceded by an abrupt rise in blood-pressure, this being followed by an acute edema of the lungs. In a case of interstitial nephritis, the same phenomenon occurred, the pressure rising to 240 mm. during an attack of asthma and dropping to 180 mm. at its close. He believes that the acute rise in blood-pressure is the cause of cardiac asthma, the distension of the insufficient left ventricle being of subordinate importance. The entire subject of paroxysmal hypertension deserves further investigation, which may throw much light upon the pathology of the circulation.

In the cases referred to above, however, it is by no means certain that the hypertension was not due reflexly to the pain or discomfort under which the patients were laboring.

TREATMENT OF HYPERTENSION.

Since hypertension may be a manifestation of any one of a considerable number of pathological conditions, it is evident that a rational therapy

must be based upon a recognition of the underlying cause. The fact, however, that the products of proteid decomposition in the intestine tend to raise the blood-pressure when absorbed, justifies a dietetic treatment of hypertension, even though factors outside the digestive tract are chiefly responsible for the condition. Such patients should tend to a milk and vegetable diet. Soups and gravies, since they are peculiarly rich in pressor substances, should as Oliver points out be entirely excluded from the dietary. Meats, of which most of us consume an unnecessarily great amount, should be reduced in quantity. Many patients thrive and are comfortable on an entirely meat-free diet; others, as Elliott points out, feel the withdrawal of meat keenly and for them a too rigid regimen would mean great discomfort. The reduction of the amount of meat taken by such patients to a small portion once or twice daily would probably be better than its complete withdrawal. Boiled meat, since most of its extractives have been dissolved out, may be given more freely than if otherwise prepared. Vegetables, fruits, starches, sugars and fats may be given freely. The amount of salt used should be reduced to the minimum consistent with palatability; if there is edema, the diet should be nearly salt-free. Fluids may be given freely unless there is cardiac embarrassment, in which case they should be restricted. Alcohol, coffee and tea should be forbidden or reduced to a minimum, and the favorable effect of an entire withdrawal of tobacco is often striking.

Excesses of all kinds, muscular, mental, dietetic and venereal must be avoided, although individual differences are great in this respect. In general, a sudden severe exertion, such as running after a street-car is more dangerous than more prolonged, but milder exercise.

Hydrotherapeutic measures are often useful. Warm baths may be given freely. Severe sweating procedures, as Miller and others have shown, are peculiarly effective in reducing high blood-pressure; they must, however, be used with caution if the cardiac function is impaired.

The drug treatment of hypertension is not often indicated. In view of the fact that a high blood-pressure is often a compensatory affair, it is perhaps fortunate that our depressor drugs are relatively inefficient. The action of the various nitrites has been studied by Wallace and Ringer, Miller, Core and others. Amyl nitrite and nitroglycerin produce a rapid and considerable, but fugitive, fall in pressure; the action of sodium nitrite is slighter, but more persistent. Erythrol tetranitrite is the most effective, but its value is greatly impaired by the intense headache it causes. The clinical place of the nitrites is in those cases of excessive hypertension, in which it is clear that the high blood-pressure itself is producing disturbances. Their action in all cases should be carefully watched.

Among less known drugs, used for the reduction of high blood-pressure, vasotonin, a combination of urethan and yohimbin, is advocated by Fellner and Staehelin, and guipsine, a glucoside obtained from the mistletoe, by Williamson.

LOW BLOOD-PRESSURE.

Infectious Diseases.—The acute infectious diseases are commonly accompanied by low pressure, which in most of them requires no treatment, sometimes as in the case of typhoid fever being even a conservative factor. In others, as in pneumonia where the chief danger to the patient

is cardiac weakness, the systematic taking of the blood-pressure is of value, since it gives us the earliest intimation of impending heart failure. Gibson holds that a "pressure appreciably below normal in pneumonia is invariably of evil omen, and any considerable fall bodes disaster. When the arterial pressure, expressed in millimeters of mercury, does not fall below the pulse-rate, expressed in beats per minute, the fact may be taken as an excellent augury, while the converse is equally true." Hare has been able to corroborate this view. In any case in which the blood-pressure, expressed as above, falls to the pulse-rate, active stimulation must be instituted, and the call for such measures is far better decided by the sphygmomanometer than by our older criteria of the failing heart, since it enables us to institute treatment more promptly.

In tuberculosis also the routine use of the sphygmomanometer is of value. Other things being equal, an abnormally low blood-pressure indicates an unfavorable prognosis, while a normal or somewhat high pressure justifies us in hoping for a good outcome.

Hemorrhage.—Wiggers has carefully studied the blood-pressure during and after severe hemorrhage and finds the behavior of the pulse-pressure, that is the difference between systolic and diastolic pressure, of special significance. "A progressive decrease in the pulse-pressure and especially a decrease in the product of the pulse-pressure and the heart-rate indicate a continuance of the bleeding. An increase of both, if permanent after several determinations, indicates a cessation of hemorrhage. A temporary increase of both, followed by a marked decrease on subsequent examinations, indicates an exacerbation." Wiggers has tested these rules both clinically and on animals and finds them very uniformly to hold true.

Hypotension after Salvarsan.—Sieskind finds that a fall in blood-pressure occurs constantly after the intravenous administration of salvarsan, in the usual dosage. In patients with normal hearts this fall in pressure is never so great as to endanger life. He considers it doubtful, however, whether we are justified, as advised by Weintraud, Geronne, Grassmann and others, in administering salvarsan for luetic disease of the circulatory apparatus. The cases of heart collapse after the injection of salvarsan, recently reported by Spiethoff, should make us very cautious in administering this drug to patients with impaired hearts. Salvarsan, he thinks, is definitely contraindicated in cases with a very low blood-pressure.

AORTIC REGURGITATION.

The only valvular lesion in which blood-pressure determinations give any diagnostic information is aortic regurgitation. In this condition, the diastolic pressure is very low as compared to the systolic, resulting in a high pulse-pressure. The latter may represent 50 per cent. of the systolic pressure. Hill has pointed out another phenomenon characteristic of this lesion. Normally, in a patient lying prone, the pressure, in the brachial and in the femoral arteries, is practically the same. In aortic regurgitation, however, the blood-pressure in the leg is constantly and considerably higher than in the arm, an observation which Hill considers pathognomonic of the disease. Hare has been able fully to confirm these findings.

THE NEWER CARDIANTS.

A REVIEW OF RECENT LITERATURE.

By WM. ENGELBACH, M. D., of the Editorial Staff.

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Recent developments, pertaining to the investigation of selective cardiants, deal almost entirely with the dosage and action of drugs or the active principles of the digitalis group. The application and dosage of these drugs have been made more accurate by an attempt at standardization, purification, absolute identification and isolation of the active prin-

ciples of the various members of this group. Attempts at definite standardization are being considered by a number of scientists in this country, who will report to the Revision Committee of the Pharmacopeia and the Department of the Pharmaceutical Association. No definite standards have been accepted up to this time, although a number of worthy methods and considerable research work have been advanced and adopted by certain investigators.

Houghton, in a paper before the American Medical Association, reviews the entire history of standardization and treats in detail the different methods involved. He gives the more improved methods as follows: *Quantitative assay*.—A quantitative estimation by pharmacological methods of the activity of the heart tonics is a much more difficult problem than is a qualitative assay. Any series of experiments would be necessary in order to decide what method or methods were best suited for this work. Too great a variation was exhibited in the results obtained from blood-pressure experiments on dogs, rabbits, etc., and such experiments are, moreover, quite a deal more complicated and difficult to carry out. He found that fairly accurate data could be obtained from the application of a solution containing strophanthin, digitalin, etc., to the exposed frog's heart, comparing the action of the drug thus tested with that of a sample of a known strength. This method, however, was finally abandoned for one which gives much better results. It seemed to him quite probable that the strength of the heart tonics could be determined from their killing power when administered to the lower animal.

Accordingly, rabbits, guinea-pigs, rats, frogs, etc., were employed for determining the minimum fatal dose of the drug. He finally chose frogs as being best adapted for this purpose. Different species of frogs vary considerably in reaction to the poisons, but the same species behave much alike. He has found it best to employ frogs of a nearly uniform size for the standardization of any particular tonic. Since it is impossible to obtain on the market frogs of exactly the same size, it is best, when one has a large number of samples to standardize, to have the frogs separated into lots by weight, those in each lot not varying over three grams; then one can use those weighing 14 to 17 grams for tincture of strophanthus, those weighing 18 to 21 grams for tincture of digitalis, etc. Frogs weighing less than 30 grams can be obtained at a very reasonable price from fishermen, as they are too small for the table. However, it is necessary that from the moment of capture they be handled with great care and kept in wet moss, etc., until they arrive at the laboratory, when they should be at once transferred to suitable ponds. The method of administering the poisons and observing results may be briefly stated as follows: Dissolve the strophanthin, or tincture of strophanthus, in normal saline solution. The strength of the medicated solution should be such that the total quantity to be injected shall not exceed 0.5 c.c. The fluid should be measured by means of very slender pipettes, graduated into hundredths, into round-bottomed capsules of about 1 c.c. capacity from which the last drop may be taken up in a narrow pipette having a long slender point, and the injection then made through the frog's mouth into the abdominal lymph-sac. Great care should be taken not to puncture the skin, as this will allow a portion of the injected fluid to leak out. After the injection, the frogs should be placed in wide-mouthed frog glasses, the plates containing about a quarter of an inch of water. It will be necessary to inject several series of about five frogs each for each sample of the drug to be assayed, a first series to the injected with

drug of known standard strength. After testing a large number of tinctures of strophanthus, he found that 0.00015 c.c. per gram body weight represented fairly well the toxic activities of an average sample of tincture prepared from strophanthus (Kombe). The minimum fatal doses of tinctures of strophanthus prepared from various lots of the drug obtained from the American market were found to be as follows:—

1.....	0.00015	8.....	0.00015
2.....	0.00026	9.....	0.00022
3.....	0.00015	10.....	0.00017
4.....	0.00012	11.....	0.00016
5.....	0.00013	12.....	0.00015
6.....	0.00015	13.....	0.00025
7.....	0.00010	14.....	0.00033

The several tinctures were prepared by one process and with the same menstruum.

The second series is to be injected with doses varying considerably in size. The third series is to be injected after the approximate dose of poison has been found from the second series. From the third series we may almost surely fix the minimum dose. A fourth series should finally be injected, which will fix the limits of strength very closely. The minimum fatal dose should kill at least three frogs out of five. If a less number die, it is best to inject another series with doses one point greater.

One very important advantage of the method above outlined for the assay of the heart tonics is the fact that various kinds and sizes of frogs may be employed at any season of the year, the only essential being that at the time the assay is made, the standard and unstandardized preparations should be tested at the same time, the frogs being exactly the same species and kept under exactly the same conditions, comparative results only being necessary, since the standard solution maintains its activity almost entirely unimpaired.

He later proposed strophanthin (Kombe) c. p., crystalline, as a stable, satisfactory, chemical standard by which to measure the value of the heart tonics of the digitalis series. With a great deal of care his colleague, Dr. D. H. Brauns, has prepared the standard strophanthin from strophanthus (Kombe) seeds, which were received in the original pods, as shown, from Mr. Lindsay, Curator of the Edinburgh Botanical Gardens and identified by the well-known pharmacognosist, Mr. E. H. Holmes, F. L. S., Curator of the Museum of the Pharmaceutical Society of London. The detailed results of their chemical and pharmacological studies will appear shortly. The strophanthin, which they have proposed as a standard, is obtained from the seeds by the following method:—

Seeds (strophanthus, Kombe, identified by Professor Holmes, London) carefully separated from the awns were ground to a fine powder and extracted with petroleum ether to remove fatty oil. The defatted drug was exhausted with strong alcohol by percolation, the alcohol recovered *in vacuo*, leaving a syrupy residue from which the strophanthin crystals separated on standing. These were then filtered out and recrystallized, giving as a final product the chemically pure strophanthin crystals.

In order to obtain considerable quantities of the crystals, a better method is to treat the dilute, syrupy, alcoholic extract with basic lead acetate, and then remove the excess of lead with hydrogen sulphide. The

strophanthin will remain in solution, from which it separates out on spontaneous evaporation. The separated strophanthin may then be purified by recrystallization from very dilute alcohol. The process of obtaining the crystals is so simple that any one having a supply of the genuine seeds can obtain material for the standard.

Summarizing his methods, pharmacologists recognize that the physiological action of digitalis, strophanthus, convallaria, etc., are so closely allied that they may be considered as one group, and may be physiologically assayed by the same method. The basis of the method of physiological assay depends upon the peculiar characteristic affinity of the heart muscle-tissue, which is most characteristically shown by cold-blooded animals, to the members of this group.

The test animals preferred are normal, healthy, medium-sized frogs of the *Rana pipiens* variety.

The M. F. G. of the unknown and the standard are obtained by injecting suitably sized doses under precisely the same laboratory conditions.

Strophanthin, Kombe, c. p., crystalline, is proposed as the standard by which the value of the members of this group shall be assayed. 0.000001 gram of this strophanthin is considered as the normal minimum fatal dose per gram body weight of frog, when properly injected into the abdominal lymph-sac, and corresponds in physiological activity to 0.000075 c.c. of standard (U. S. P. 1900) tincture of strophanthus, which represents the average activity of first-class commercial strophanthus, Kombe, seeds as they appear on the American market. Ten times a normal minimum fatal dose (M. F. D.) per gram body weight of frog represented by 0.000010 (0.000001x10) of strophanthin is considered as a normal Heart Tonic Unit (H. T. U.); hence, each gram of strophanthin contains 100,000 H. T. U.

The number of H. T. U. in any preparation of the heart tonics of the digitalis series, knowing the H. F. D. for *Rana pipiens* of the unknown and the known, may be determined by the formula:—

$$\frac{\text{No. of H. T. U. per (M. F. D. of standard)}}{\text{gram of standard (M. F. D. of unknown)}} = \text{H. T. U. of unknown};$$

$$\text{e. g.: } 100,000 \frac{(0.000001)}{(0.000075)} = 1333 \text{ H. T. U.}$$

Since the M. F. D. of the unknown and standard is always tested under the same conditions at the same time, seasonal and other reasonable variation in the resistance of the test frogs will not make any difference in the end results, as the increased or decreased resistance is in the same direction and of the same degree:—

$$\text{e. g.: } 100,000 \frac{(0.0000009)}{(0.0000675)} = 1333 \text{ H. T. U.}$$

Besides the above methods of obtaining more accurate and stable preparations, the most notable advances concerning the isolation of the more efficient active principles have been made in regard to digitoxin and digipuratum. These principles, on account of their rapid action, have been given most consideration, and the following reviews reflect the opinions of the investigators in regard to the value of these elements as compared with other heart stimulants.

The active principle of the digitalis leaves, digitoxin, has rarely been

used for therapeutic purposes, as the crystalline preparation is dissolved with difficulty and may be prescribed only in fractions of a milligram. Furthermore, it has a tendency to disturb the stomach. Cloetta succeeded in isolating from the leaves an amorphous digitoxin, "digalen." This preparation, when given by mouth, does not give rise to disorders of the stomach. Experiments on animals, moreover, have shown hypodermic injections to cause no irritation. "Digalen" may be safely applied, therefore, per os, per rectum, intramuscularly and intravenously. Cloetta states that digalen has the advantage over the galenic digitalis preparations in producing a regular effect even in cases where digitalis proves ineffective. The effect ensues rapidly without a latent stage of development, the remedy, therefore, is of the greatest importance in weakness of the heart which suddenly supervenes in the course of acute infectious diseases.

According to Naunyn, the action of digitalis has its limitations in that the employment of the remedy becomes impossible if it is no longer tolerated by the patients, who then are precluded from its use, more especially so, if on a previous occasion it has been administered in too large doses followed by phenomena of poisoning. There also occur cases in which at the outset small doses are not tolerated. In such cases or when the remedy fails to take effect, the desirability of substitutes is felt. Naunyn tried many remedies, but did not find any one of them to be a suitable substitute, neither *strophanthus* nor the toxic constituents of *convallaria majalis* or of *laurus nobilis*. He has given much attention to digitoxin (Schmiedeberg) which he employed per os and by way of enemas; and he has observed good results even in some cases where *infusum* or *herba digitalis* failed. Its continued use, however, has an undesirable cumulative effect; the application per rectum likewise has its limits, owing to the irritation caused by it. He does not favor this mode of application. Generally, infusions of digitalis act more slowly than is sometimes desirable. In most cases the effect does not manifest itself until the third or even the fifth day, when the usual doses are given. This absorption stage is shortened in giving hypodermic injections of digitoxin soluble Cloetta. Doses of 0.3 milligram, applied from one to three times daily, produce an effect after twenty-four hours. Such rapid effect is of the greatest importance in the acute cardiac weakness in infectious diseases. Naunyn states that his remarks regarding Merck's digitoxin apply likewise to digalen, since this latter preparation is impure digitoxin. He also tried hypodermic injections, formerly of *inf. fol. digit.*, but the results were very unsatisfactory; the remedy was not tolerated by the patients, caused rigor, etc.

Walti administered digalen in severe cardiac incompetency and obtained very gratifying results in all his cases.

Bibergeil recommends digalen as being readily soluble in water, non-irritant, and easily diffused. A great advantage of this preparation consists in that it does not give rise to indigestion and loss of appetite, and that it agrees with patients who vomit after taking digitalis infusion. In its effect on the circulation system it is at least of equal value with digitalis infusion; over which, however, it has the advantages of admitting of exact dosage, of rapid action, and of apparently no cumulative effect. Its indications for use are the same as those of digitalis.

Kottmann used digalen intravenously and obtained the effect two to five minutes after the injection, there being demonstrable a sudden increase in blood-pressure which continued for at least twenty-four hours, in many

instances for several days. The frequency of the pulse was seldom influenced, but frequently the quantity of urine was extraordinarily large, as much as 8 litres in twenty-four hours. He emphasizes the fact that intravenous injections afford the possibility of rapidly producing a digitalis effect, and that this mode of application is of the greatest importance, particularly in cases of acute weakness of the heart, as in cardiac asthma. In the case of intravenous injection, the whole quantity injected suddenly takes effect, whilst the rapid excretion presumably prevents intoxication.

In the majority of his cases Klemperer obtained good results after the administration of digalen, a stronger pulse, abatement of dyspnea, and considerable diuresis with the disappearance of edemas. In several cases, when administered *per os*, it seemed to display a genuine digitalis action; and Klemperer recommends the preparation as a substitute for the frequently unreliable leaves, since it permits of exact dosage.

Kollick concludes from his observations that digalen is more reliable than the infusion of digitalis leaves, that its dosage is more accurate, and results are obtained more quickly. Furthermore, no undesirable effects were noticed, as in all instances the drug was well tolerated.

The experimental work of Baccarani shows that: 1. Digalen produces a rapid effect on the blood-pressure and diminishes the frequency of the pulse. 2. Such effect on the vascular system continues for some time after taking the remedy, but does not last very long. 3. The drug is to be administered, therefore, in fractional doses several times daily; and as it is well tolerated, the patient is not thereby inconvenienced. 4. The diuresis increases considerably, doubtless owing to the increase in the blood-pressure.

In the experiments of Hochheim, digalen proved to be a good cardiac tonic. It increased the blood-pressure in cases of arrhythmia, exerting a regulating influence on the action of the heart, as it does away with, or considerably diminishes, at least, the number of extrasystoles. If the action of the heart is greatly accelerated, it diminishes the number of the contractions. In states of congestion, due to disturbances of compensation, it produced a pronounced diuretic effect. The copious diuresis manifested itself in most instances during the period from the second to the third day of the digalen treatment; and after discontinuing the use of the remedy, the quantity of urine excreted during twenty-four hours generally exceeded the normal quantity for several days. With the increase of diuresis the phenomena of congestion subsided. The hypodermic injections generally gave rise to burning pains, lasting from one to several hours; and occasionally to soft swellings, which in some instances did not disappear for a few days. By resorting to intravenous injections, local phenomena of irritation may be entirely avoided. Symptoms, that might be regarded as toxic disturbances, were not observed. Nausea, vomiting, diarrhea or giddiness never manifested themselves. In Hochheim's opinion digalen enables one to obtain a reliable digitalis effect—more especially in urgent cases—by way of hypodermic or intravenous injection. Hence, this preparation must be regarded as a very valuable remedy in cases of pronounced inclination to vomit and in unconscious patients after laparotomy, more especially after operations upon the stomach.

Haffter made use of digalen in a severe case of Basedow's disease, which defied every other treatment. An injection of two grams reduced the frequency of the pulse (144 to 160) almost to normal (96 to 100), at which it remained during seven to eight days. After that time a

further injection was necessary. Since the employment of this treatment, the condition of the patient has improved.

De Renzi draws the conclusion that Cloetta's drug has the same action as digitalis; but the employment of the new preparation is more convenient, more reliable in effect and unattended by bad effects. Cumulative and irritant effects after its administration are far less likely to ensue than after the use of digitalis.

In comparing digalen with digitoxin, Ceconi and Fornaca conclude that the former displays its action with equal rapidity and has the following advantages: 1. It admits of much more convenient dosage and affords greater facilities in the mode of application. 2. It agrees better with the patients, both as regards single doses and the total quantity used during the treatment. 3. Phenomena of intolerance, more especially such symptoms as are due to accumulation of the remedy in the organism, are of very rare occurrence.

Haberfeld entertains a similar opinion that digalen is non-irritating to the stomach, is rapid and non-cumulative in action, on account of its rapid excretion through increased diuresis; further it admits of exact dosage and is always constant in composition.

Thurnheim corroborates the advantages of digalen as stated by the preceding investigators. Moreover, in his experience it sometimes gave results in cases in which digitalis proved ineffective.

Maass administered digalen intravenously and recommends this preparation for its harmless effect and rapid action.

Freund remarks that digitalis therapeutics, as long as we were dependent on the drug, was often unreliable, whether digitalis was given in the form of infusions or in powder. The amount of efficacious substances, contained in the leaves, is known to differ very much according to the place, the time of the year when they are gathered, and the age of the drug. These disadvantages, he believes, are absent in the case of digalen. The solution does not spoil and keeps a long time without losing the digitalis effect. It has a further advantage, which not one of the digitalis preparations hitherto in use possessed—namely, it may be applied hypodermically, and thus affords the possibility of using it in the case of patients who are subject to vomiting and, as a consequence, are unable to take anything orally. He refers to digalen as the first solution of digitalis that permits intravenous application, and thus renders possible an almost immediate effect; whereas, after hypodermic injections, it takes two hours, and after other modes of application twelve to twenty-four hours for the effect to set in. According to his experiments it produces prompt and lasting effects. Even after a dose of only five drops, introduced into the lymph-sac, a distinct digitalis effect sets in after a quarter of an hour. The systoles become more pronounced and more prolonged (from one second to sixteen seconds). This effect continues for about an hour; if further doses are employed, the action of the heart becomes irregular. If dropped directly on the heart, the same curves result. He remarks that with regard to weakness of the heart occurring in infectious diseases, the modern digitalis therapy places at our disposal an important remedy in the form of this digitoxin, which enables us to combat it by way of hypodermic, intramuscular and intravenous application. It acts more intensely than camphor and caffeine and more rapidly if employed in the form of intravenous injection, this latter being the only form to be considered in case of impending collapse. This observer reports his successful administration of the drug in weak-

ness of the heart after chloroform-narcosis and in a case of acute dilatation consequent on over-exertion.

Livierato states that digalen produces a rapid effect, which is one of its principal advantages in practice. It is well known that the infusion acts slowly and that the effect is always preceded by a latent stage of development. Such latent stage is considerably shortened by the employment of this preparation of digitoxin. Its rapidity in producing an effect proves its practical value in cases of unforeseen weakness of the heart, as appears in acute infection. Digalen exerted a considerable and constant influence on diuresis; the quantity of urine increased from 650, 800, to 3,200 c.c. At the same time the specific gravity decreased and the albumin no longer appeared in the urine. The diuresis continued to be copious during the next few days. Such increase in diuresis doubtless is a consequence of the rise in the blood-pressure. The rise, however, ensues rapidly, and in the case of hypodermic injections of from 2 to 3 c.c. it sets in in twelve to thirty hours after the injection. If still larger doses are resorted to, the effect on diuresis is even more pronounced, as well as on cardiac dulness and blood-pressure.

Mann's experiences induce him to attribute to digitalis a much greater value than to strophanthus. However, it cannot be denied, he says, that the usual tincture of digitalis is frequently very slow in action. Among the efficacious preparations are the digitalin granules (Nativelle) and the digitoxin, recently discovered by Cloetta, which is soluble in water. A study of the various cases shows that the results obtained with the latter are substantially identical with those derived from the use of digitalis, viz., enhancement of the blood-pressure, regulation and decrease of the pulse, modification of the general disturbances in keeping with the re-establishment of the circulation. An increase in keeping in diuresis and simultaneous decrease of the edema, as well as other concomitant phenomena, dyspnea, sense of anguish, etc., were invariably in evidence.

Pittini and Pietro conclude from their experiments that digalen may be employed with good results in all cases of cardiac diseases in which the use of digitalis is indicated. The more convenient form of application, the more exact dosage, the stability of the preparation and, above all, its rapid effect, lead to the conclusion that, in producing this remedy, Cloetta has succeeded in placing at the disposal of the profession a very valuable agent for the treatment of cardiac diseases.

Avanzino comments upon the marked diuretic effect of the soluble digitoxin and recommends this preparation on account of its serviceability. Schwyzer found digitoxinum Cloetta to be superior to digitalis preparations in the market. It was employed in all cases in which the use of digitalis was indicated. If administered by the mouth it produced an effect more rapidly than digitalis powder; after hypodermic or intramuscular application the effect occurred in a few hours; intravenous injections were followed by an effect immediately. Digalen had no cumulative effect and did not last as long as digitalis. But as soon as the digalen effect had been obtained, it was maintained by small doses. Its principal advantage consists in that it admits of almost painless hypodermic application; and that in urgent cases it may be employed by way of intravenous injections with immediate results.

Reitter noticed improvement in myocardial degeneration after the administration of Cloetta's digitoxin. In arrhythmia the beneficial effect was unmistakable, provided the cardiac muscle was not too greatly af-

fected. Such rapid effects could not be produced hitherto with any of the other preparations in use. Another advantage consists in the absence of phenomena of poisoning.

In the treatment of cardiac and renal lesions with digalen, Marini refers to the increase in the tonus and the lessening of the peripheral arterial pressure. These facts, he believes, are dependent on the lessening of the vascular tension. Owing to the fact that the drug reduces the tension of the renal vessels and thus causes a more extensive and more rapid flow of blood, it gives rise to a copious diuresis. Digalen, according to Marini, is preferable to digitalis, because it rapidly exerts a regulating influence on the function of the heart, as it does not give rise to a cumulative effect; for, even in the event of its use being continued for a long time, the remedy seldom causes a serious irritant effect. Digalen, which is very serviceable in chronic lesions of endocarditis and myocarditis, is likewise productive of excellent results in the case of nervous cardiac disturbances and in protracted infectious diseases.

The sphere for the use of digitoxin, according to Marr, is extensive. It slows and strengthens the impulse of the heart, is a good vascular stimulant, and its peculiar renal effect constitutes it an ideal diuretic. It is indicated in rapid and weak action of the heart, low tension of the arteries, dyspnea, pulsating jugularis, dark complexion, scanty and dark colored urine, and general hydrops. It is one of the best aids in the first stages of pneumonia and many other states of inflammation. In the early stages of scarlatina it is a most serviceable drug.

In a case of cirrhosis of the liver, accompanied by defects of the mitral valve, Cramer observed that the use of digalen was followed by a rapid and lasting digitalis effect on the pulse and general condition before, as well as after, the puncturing of the exudation. A favorable influence was exerted on the diuresis at the same time; but when the use of the remedy was discontinued, the diuresis diminished again.

Freund states that this amorphous substance does not only dissolve more readily in water, but is also more easily diffusible than the crystalline glycoside; and it is to this fact that he attributes the superior wholesomeness of digalen as compared to digitalis leaves and to the infusions prepared from them. Not only does digalen apparently affect the stomach less than digitoxinum crystallisatum, but it also affords the possibility of obtaining a digitalis effect without the medium of the stomach, viz., by way of hypodermic and even intravenous injections of the amorphous modification of the original substance, thus giving the benefits of digitalis therapy to many patients with whom the digitalis leaves do not agree.

Kohn believes the greatest sphere for the use of digalen is cardiac disease with disturbances of compensation, or with renal complication, in which cases it may be administered per os or subcutaneously. It proves likewise useful in cases of moderately advanced degeneration of the cardiac muscle, and in diseases of the aorta accompanied by mitral insufficiency.

According to the observations of Calzolari, during pregnancy digalen diminishes in an almost constant manner the frequency of the pulse, enhances in most cases the blood-pressure, and always increases the excretion of urine. Its effect sets in rapidly and lasts at least two hours. It has never given rise to contraction of the uterus nor has it injured the fetus in any way whatever.

Pesci resorted to digalen treatment in the treatment of pneumonia and

found that the preparation exerted a very favorable influence on the pulse, on the blood-pressure, as well as on leucocytosis, since it causes the crises. He also recommends its employment in purely aortic insufficiency with cardiac asthma or angina pectoris. In the latter case, he says, a great rise in blood-pressure is no contra-indication; and in attacks of angina pectoris the drug may be employed intravenously. If it is desirable to produce a rapid effect as, for instance, in severe cases of cardiac asthma, the remedy should be employed intravenously; which method is advisable also in the case of cardiac insufficiency in acute infectious diseases, such as pleuritis, pneumonia, etc. He accentuates the fact that, as compared to other similar preparations, and to digitalis itself, this preparation has the advantage of admitting exact dosage and thus precludes certain drawbacks and dangers, and ensures the desired effect. Its greatest and indisputable advantage, however, consists in that the remedy is pre-eminently suitable for intravenous injections; and this form of application becomes imperative in urgent cases, and frequently so in cases where digitalis is not tolerated by the stomach. Intravenous injections always produce reliable, rapid and good results.

Hale has carefully studied the action of digalen in comparison with other digitalis preparations. He reviews the literature, showing that certain claims made for digalen are incorrect; that it is not devoid of cumulative action; that it possesses marked irritating properties resulting sometimes in edema and thrombosis; that it causes disturbances of digestion apparently as often as the older preparations; and that its effects do not appear more rapidly than from corresponding doses of the leaves of digitalis. Other investigators are quoted who show that digalen has no special properties in acute cardiac failure; that its effects did not appear more quickly when given subcutaneously than by the mouth. Intravenous injections, however, gave results in two to five minutes, but the doses required were so large as to render this method of administration dangerous. In regard to the experimental work on animals, it was found that digalen is much less active than the crystallized digitoxin. The experimental work of Hale showed variations in the strength of digalen, indicating that deterioration occurs with age. In a comparative study of the action of digalen, digitoxin and digitalin, this author found that digalen is much less active than crystalline digitoxin, and of about the same potency as digitalin. This lends weight to the contention of some observers that digalen is not identical with digitoxin, but is only a high percentage of digitalin. With regard to the general action of digalen on animals, it appears to possess considerably more stimulant action on the central nervous system than other digitalis preparations. In most cases, the early symptoms of absorption were convulsive movements. This agrees with the clinical effect, observed by Teichman, of excessive nervous stimulation following intravenous injections. In regard to digipuratum, Hale concludes from his biological tests that it is constant in composition, and appears to be an assayed product. As to its efficiency, he believes it to be of the same activity as the strongest official preparation on the market. From his experiments Hale could draw no conclusions as to the presence or absence of secondary toxic effects following the use of digipuratum.

Focke also reports unfavorably on the action of digalen. He bases his conclusions upon experimental and clinical studies of the action of this product.

Boos, Newburgh and Marx discuss the comparative value of the more

recent active principles of digitalis. The greater part of their work has been done with digipuratum. It was tried in 108 cases. Eight cases are considered in detail. Special illustrations and charts are included in the article, which exhibit all the phases in the activity of digipuratum. It has long been known that one of the factors which renders digitalis medication difficult is the tendency of this drug to produce gastro-enteric disturbances. It was with the hope of lessening the irritant action of digitalis that Gottlieb essayed, by chemical means, to remove the digitonin from the leaf-extract. He succeeded in obtaining a product which is free not only from digitonin, but also from 85 per cent. of the other bulky and inactive matter, which ordinarily passes into a leaf-extract. When Gottlieb compared the action of his purified product with that of the original leaves, he found that he had recovered practically all the digitalin and digitoxin contained in the crude leaves. To this purified product Gottlieb gave the name of "digitalis depuratum," or "digipuratum," for short.

This purified digitalis extract is a yellow liquid. The active principles contained in it are insoluble in cold water and acids, but easily soluble in dilute alkalies, a property which ensures their ready absorption from the intestine. The yellow fluid is standardized physiologically and is then taken up with sugar of milk to form a powder. The powder obtained is further diluted with sugar of milk until the resulting product has a definite and constant pharmacological strength. In his physiological tests Gottlieb uses *Rana temporaria* (the German field frog), obtained during the months from July to October, and kept in captivity as short a time as possible before use. His unit of strength is the minimum amount of the extract, which in thirty minutes will cause systolic stoppage of the heart of a frog weighing 30 gm. This quantity Gottlieb calls a "frog unit." By standardizing a large number of the best leaf-powders obtainable, Gottlieb found that the ordinary dose of the powdered leaves, 0.1 gm., varied in strength, in the different samples, from 4 frog units to 12. Eight frog units being the average, Gottlieb chose this strength for his purified extract. Digipuratum is therefore prepared as a powder having the constant strength of 8 frog units to each 0.1 gm. of the powder, corresponding to the average strength of a single dose (0.1 gm.) of the crude powdered leaves. For greater convenience of dosage, digipuratum is usually dispensed in tablet form, each tablet containing 0.1 gm. of the powder. These tablets have an agreeable vanilla flavor, and are taken readily by all patients. In the treatment of broken cardiac compensation, Boos, Newburgh and Marx gave the drug as suggested by the clinicians mentioned—namely, in the form of so-called treatments; that is to say, they employed the ideal digitalis medication, giving large doses in as short a time as possible. They were enabled in this way to determine if the drug, when given in sufficient quantity rapidly to produce its physiological effect, is really free from the irritating substances which usually make similar dosage of the crude drug an impossibility, and to determine if, under these circumstances, this drug exhibits a lesser tendency to produce cumulation than the crude preparations. They gave digipuratum as a rule in treatments of twelve tablets in four days; four tablets the first day, three the second day, three the third day and two the fourth day (that is, 12 gm. or 18 grains in four days). In many of the more serious cases, they were obliged to continue the drug in doses of one or two tablets for a longer or shorter period.

Each of the 8 cases shows interesting features. The diuresis is ef-

ficient in all the cases. In one case the diuretin probably played little, or no part in producing the phenomenal urinary output. Four cases show the marked effect of digipuratum on the slowed pulse-rate. The most remarkable case was a patient sent into the hospital in a moribund condition and little hope for her life was entertained. She reacted very quickly to digipuratum, however, and compensation was established in a week. The patient has been under the care of either Boos, Newburgh or Marx since leaving the hospital. At first she needed two tablets of digipuratum daily for several months; after that the dose could be gradually diminished until now, after one year, she takes on the average only four or five tablets a week. At times she goes a week or ten days without the drug. She is comfortable, looks after her household duties, and makes many visits, although she lives up one flight of stairs. The physical signs are the same as when she left the hospital. In some of the cases the first digipuratum treatment gave little or no result, while the second was very efficient. Four cases illustrate the good results which may often be obtained by combining digipuratum medication with venesection, or the removal of fluid from the body by tapping. In the second case the efficient diuresis which began on the tenth day was due to a combination of digipuratum with the fluid extract of apocynum. The blood-pressure was rarely affected. There was no vomiting or diarrhea in any of the cases. Digipuratum has now been in use at the Massachusetts General Hospital for over a year, and more than 180 cases of primary heart disease, or secondary cardiac involvement, have been treated with it. The effect on the urinary output had been very prompt in most instances. There was not a single case of vomiting or diarrhea; in fact, the vomiting of a number of cardiac patients at entrance was promptly stopped by the drug. Cumulative poisoning has never been observed. One of the early patients, a boy of sixteen, was given 106 tablets in six weeks; at no time was there any suggestion of digitalis poisoning. In one or two instances, the house officers were made uneasy by sudden drops of forty or more beats in the pulse-rate, but no disagreeable symptoms followed in any case. It must be borne in mind, however, that digipuratum is a digitalis preparation, and that as such it must necessarily have a tendency to produce poisoning by cumulation. But as regards this drug, the tendency is much diminished, so that it is possible by means of this agent to push digitalis therapy in a manner heretofore unknown.

SURGICAL AND MEDICAL SHOCK.*

A REVIEW OF RECENT LITERATURE (SINCE 1899).

By J. R. GERSTLEY, M. D., of Chicago.

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The student, considering the cause of death following severe trauma, or following laparotomy, and then turning to the bedside and seeing the fatal termination in typhoid and other septicemias, must observe that frequently the clinical pictures in all these conditions are much alike. Can the apathy, the pallor, the thready pulse and the sighing respiration in all these conditions be traced to one identical, original source? Much has been written upon this subject, and much can be learned from the opinions expressed. Let us first turn to the fatal depression following trauma or laparotomy—the typical surgical shock.

The cause of this phenomenon has been much disputed. At first, many claimed that the heart was the great factor. Others considered the nervous system to be at fault, still others included heart and vessels, and finally Crile, whose work we all know, brought forward the idea that surgical shock was due primarily to failure of the vasomotor centre. The vessels lost their tone, the blood stagnated in the viscera, and the heart finally failed, for lack of work to do. Under these circumstances heart stimulants could be of no value—as he proved—and he looked for other means of supporting the circulation. The object in view was to find some means of forcing the blood engorging the viscera, out into the general circulation, and he now turned to mechanical means. Saline infusions theoretically should be ideal, as they should supply fluid for the still sound heart to work upon, but for some reason or other they did not prove as successful as might be expected. Still determined to find some agent giving tone to the vascular system, Crile used adrenalin and found in this a powerful drug, but its effects at best are only temporary, and when it is stopped its value ceases at once. It must be given intravenously, continuously, and by the hour to be efficient, and this is almost impossible. Finally, when all the work was through, Crile decided that the very best means that he had of supporting blood-pressure for any continuous time was by bandaging the extremities, or better yet by a pneumatic suit, with which he could mechanically raise and sustain arterial tension sometimes 75 mm. of mercury.

Not analyzing his results, but thinking only of the theory upon which they were based, the profession took to the use of intravenous infusions which are practised indiscriminately even to-day, but a careful review of the work of Allport, Balloch, Kemp, Hare, Cushing, Eisendrath and Straus, and Bloodgood, brings out the fact that in severe shock infusions are worthless unless hemorrhage has been present. The tendency seems to be to use infusions less and less for the purpose of stimulation, and more and more for the purpose of flushing out toxins in toxemia and supplying

fluid to the tissues in cases of dehydration as in cholera. An enormous amount of work has been done upon the subject, but experimenters have never gotten beyond the stage of adrenalin and the mechanical suit. Two advances, however, have been made. First, Locke's solution has been substituted for plain sodium chloride. Much experimental work has been done upon the toxicity of pure sodium ions, and the conclusions from experimental and clinical observations are that the sodium-calcium solutions are more beneficial. Secondly, Stewart and Pike working at the University of Chicago have brought out the point that cardiac action is dependent upon intracoronary pressure. When they perfuse the coronaries of an isolated heart with fluids at a pressure of 80 mm. of mercury, the heart starts beating. Crile at once takes advantage of this in his new scheme of resuscitation. Admitting that intravenous infusions of dilute adrenalin have not been attended with the happiest results, he injects the infusion into an artery and *toward* the heart. This wave of increased pressure is transmitted into the coronaries and the results are better than the older intravenous method. The latest texts on surgery recognize this scheme as valuable.

Now, while all this work on therapy was being carried on, the principle upon which it was based, was being undermined. Malcolm in England, Porter and Quinby, and Seelig and Lyon in this country, have shown definitely that in surgical shock the peripheral vessels are contracted, not dilated, and that the vessels are still under nervous control. The work of the latter observers particularly, has been most conclusive, but they do not explain the fall in blood-pressure which invariably accompanies severe shock. And here the matter stands. Until the recent work of Henderson of Yale, we may say that even after the enormous amount of work upon the subject, all we know about surgical shock is that it is accompanied by a fall in blood-pressure, that this fall is combated temporarily by adrenalin and more permanently by a pneumatic suit—and that intracoronary pressure is an essential to cardiac activity.

Now let us turn to the medical side of the question. Here we have a toxemia, a poisoning of every part of the body, and the question as to the primary cause of death becomes more complicated. That there is a fall in blood-pressure in many severe infections, there can be no doubt, but whether this fall is due primarily to cardiac or to vasomotor weakness, or to both, is still not absolutely settled. The writings of Blake and Cornwall, particularly in regard to pneumonia, and of Secor rather emphasize the importance of cardiac weakness. On the other hand, Jane-way, Robinson, Broadbent, Miller, Worster, Williamson, Sonnenkalb, Stowel, Hare, Howland, and Hirschfelder, either call attention to the fact that in many cases of death from septicemia, there are not sufficient pathological findings in the heart to account for this termination, or else they directly blame the failure of the vasomotor centre. Indeed they show that often in uncompensated heart trouble blood-pressure may be raised. Much experimental work has been done upon the subject. The pioneer researches of Romberg and Pæssler go to show that in acute infections it is vasomotor failure that kills. The heart functionates to the last. Krehl examined quantitatively fatty changes in hearts from septic cases and found too little fat to markedly impede the work. Aschoff and Tawara, after examining hundreds of sections, concluded that many pathological findings in hearts were artefacts. Hasenfeld and Fenevessy found that hearts poisoned with phosphorus were still capable of respond-

ing to increased demands. Heincke showed that in peritonitis respiration failed first as it did in surgical shock. So the consensus of opinion is that in many fatal cases of medical disease, heart failure is not the primary cause of death, but is secondary to failure of the vessels. With this idea in view, identically as the surgeons were working, so did the medical men begin studying the effect of drugs upon blood-pressure, and like the surgeons, medical men were considerably disappointed. The work of Pæssler and Miller experimentally, and of Cook, Stowell, Webster, Cabot, Brown, and Howland, all show that our well-known drugs, as alcohol, strychnine, digitalis, etc., are not as effective as was thought. Almost every observer has decided that some one drug is of value, usually caffeine or camphor, but the results are at such variance that nothing has been gained except to show that vasomotor drug therapy is not a great success. Like the surgeons, the medical men tried infusions, and with similar results, and so still other means have been employed in combating the fall of pressure. Howland, after a most excellent review of the subject, finds that cold air is far more efficient in raising and sustaining blood-pressure than is any drug. He finds children with pneumonia have a pressure sometimes 15 mm. higher when out of doors than when in the ward, and thinks that this is the reason that the open-air treatment is more effective in winter than in summer. Webster, Osler, and Edwards value the bath highly, and Brown finds Nauheim baths in pneumonia of greater value than any medication. Interesting is it to see how medical thought runs parallel to surgical. Not satisfied with the results of drug therapy, arguing on a basis of vascular failure, the profession has now taken to the use of adrenalin. The writings of Miller, Calderon and Floersheim in this country, and Falta and Ivocie, Haeberlin, John, Ed. Koll, Von der Velden, and Lichtwitz and Hirsch abroad, speak of the great value of this drug in elevating blood-pressure and thus sustaining the heart, the only danger being in causing too great a rise of pressure for the heart to overcome. Indeed, the infusions as a vehicle are given up, and the ordinary 1/1,000 extract is given either intravenously, intramuscularly, or subcutaneously. The writers speak most highly of this drug and indeed there seems in these medical cases an unusual indication for it, for some recent work goes to show that in shock occurring in septicemias there is a deficient amount of adrenalin in the circulating blood. So to sum up then, in fatal medical, as well as surgical, cases, death occurs at times when the heart does not seem at fault, and where the only explanation of the decreased vascular tonus *has been* in failure of the vasomotor centre. In combating this condition, medication has failed, infusions have failed, and finally not satisfied, the profession has found the most powerful remedy in adrenalin. In surgery, as accessories, the pneumatic suit, bandaging and posture are employed, and in medicine, cold air and the bath.

Until recently no absolutely satisfactory explanation of the fall in blood-pressure has been offered, since the disproving of the vasomotor theory. Now physiology steps forward with Henderson's acapnia theory. As this was recently reviewed in an editorial of this JOURNAL, we shall just touch upon it. Henderson has shown that excessive breathing causes a marked diminution in arterial carbon dioxide, oxygen being unchanged. Now carbon dioxide is the natural stimulant of the respiratory centre, and when it is removed in large amounts as in excessive respiration from pain, or by escaping from the abdomen during a laparotomy, respiratory failure may occur. Indeed, this is the usual form of

death in shock. In the great majority of Crile's experiments, respiration ceased first, while the heart continued beating for a short while, and many clinical observations bear out the same truth. However, if a second stimulus to respiration, as pain, is present, then the centre will functionate even if the carbon-dioxide content in the blood is insufficient. As a result secondary changes develop. Due to the acapnia—the diminished carbon dioxide—changed osmotic conditions prevail in the circulation and sodium chloride and fluid leave the veins for the tissues. Consequently not enough blood is brought to the right heart, then comes a secondary fall in blood-pressure, though the vasomotor centre is working its hardest to maintain tension, and finally the heart fails for lack of fluid to work upon,—not from vasomotor failure, but from venous failure. Henderson has done a beautiful piece of work and his results are most convincing.

This theory of venous failure, like the others, is not without some medical equivalent. In 1906 Sewall wrote on the physiology of the veins, and remarked on the important factor in cardiac activity of high or low venous pressure. Indeed, forty years ago Fisher compared the depleted circulation in cholera to that in profound shock—in which intravenous infusions were only a temporary aid and then escaped rapidly into the tissues. In acute infections likely to end in shock there is retention of salt and water, and Weselkin has shown that an atmosphere of 5 to 10 per cent. CO_2 has considerable effect upon temperature.

So we see that the new acapnia theory may be of some value to medical men. Indeed, Hirschfelder in his latest work upon the heart thinks the excessive breathing in infections, from fever and toxemia, may be a factor worth considering. Is it not interesting to see how the advances in surgical and medical thought upon this subject have gone hand in hand for the last ten years? Whether this new theory, like the use of adrenalin, will perhaps become more useful to the medical than to the surgical profession, time only will tell.

CONGENITAL HEART DISEASE.

A REVIEW OF RECENT LITERATURE.

By ALFRED FRIEDLANDER, M. D., of the Editorial Staff.

1. Reilly and Smith: Heart Disease in Infancy and Childhood. (*Amer. Journ. of Obstet. and Dis. of Women and Children*, May, 1910.)
2. Fetterolf and Gittings: Anatomy of Child's Heart. (*Amer. Journ. of Obstet. and Dis. of Women and Children*, February, 1911.)
3. Pekar and Tezner: Studies of Heart Function in a Case of Congenital Ectopia Cordis. (*Jahrbuch fuer Kinderheilkunde*, September, 1910.)
4. Fulton, Judson and Morris: Congenital Heart Shock Occurring in a Father and Two Children. (*Amer. Journ. Med. Sciences*, September, 1910.)
5. Luna: Congenital Heart Lesion with Hemiplegia. (*La Pediatría*, April, 1910.)
6. Weber and Dorner: Pulmonary Stenosis and the Secondary Blood Changes. (*Lancet*, I., p. 50, 1911.)
7. Wachenheim: Congenital Heart Lesion without Cyanosis. (New York Academy of Medicine, Section Pediatrics, October 3rd, 1910.)
8. Graham: Congenital Heart Lesion without Cyanosis. (Philadelphia Pediatric Society, October 11th, 1910.)
9. Kohl: Congenital Malformation of the Heart. (*Centralbl. fuer. Allgemeine Pathol.*, XX., p. 1089.)
10. Krostein: The Closure of the Ductus Botalli. (*Archiv. fuer Gynäcologie*, Bd. 90.)
11. Bauer: Congenital (syphilitic) Myocarditis. (*Allgemeine Wiener Medizin. Zeitung*, May 17th, 1910.)

Reilly and Smith have carefully analyzed 50 cases of heart disease as found in dispensary practice. The 50 cases occurred among 1,500 cases of all kinds treated between March, 1907 and June, 1909. They thus constituted $3\frac{1}{3}$ per cent. These 1,500 cases were essentially medical and the figures thus give a very fair idea of heart involvement. Among these 50 cases, there were 4 of congenital heart disease, giving a proportion of 8 per cent. of the heart cases. If the percentage of congenital hearts is estimated on the basis of the whole 1,500 cases, the percentage of congenital lesions is 0.3 per cent. Of the 4 cases, the ages varied from five and one-half months to nine years. The history given was either that the baby had been a blue baby at birth or that the mother had noted an abnormal heart action from birth. In the two older children the chief complaint was shortness of breath. As is usual in the congenital lesions, the definite diagnosis (anatomic) could not be made.

Fetterolf and Gittings made sections and dissections of the bodies of infants, which had been injected with 10 per cent. formalin and then frozen. The horizontal position of the heart in infancy was well exemplified. At its greatest depth the heart reached from sternum to vertebræ. The blood from the inferior vena cava was directed upward by the Eustachian valve and not to the left as is commonly supposed. The foramen ovale lay in an almost horizontal plane and was not vertical. The bicuspid orifice was practically vertical and opened to the left and slightly forward. The mitral orifice lay in a plane practically at right angles to that of the bicuspid. The relation between the thoracic viscera was very clearly pointed out by these sections, and certain special peculiarities of physical diagnosis in very young children, otherwise not satisfactorily explained, were made perfectly clear. For those interested, the original article may be consulted with great profit.

Pekar and Tezner had the opportunity of making a detailed study of the heart action of an infant with complete congenital ectopia cordis during the first week of life. The autopsy later showed that there was a patent foramen ovale polydactylism. The cardiogram showed nothing specially abnormal. Despite the anomaly, the heart showed rhythmic contraction of its several portions. Respiration was very shallow, and its effect upon the cardiogram therefore not particularly marked. The authors then studied the effects of mild galvanic currents upon the heart. It appeared that as a result of the passage of the electric current through the heart, the action of the heart was greatly accelerated. Closure and, to a greater extent, opening of the current caused marked, short contractions partaking of the character of extrasystoles. As a result of stimulation of the vagus, there was a marked slowing of the rate of heart contraction, sometimes indeed a temporary stoppage in diastole. Fulton, Judson and Morris report the cases of a father (*æt.* forty-two) and two children (one in the first year of life), all of whom showed definite Stokes-Adams syndrome. Degeneration of the auriculoventricular bundles could be apparently excluded by the authors, who regarded the condition as being congenital, resting either on anatomical or physiological basis. They point out that a pulse of 42-60 in a child under one year of age, without very marked symptoms, is of itself of the greatest rarity.

Luna reports the case of a three and one-half-year-old child who had been perfectly well up to the age of one and one-half years. After a fit of crying, with vomiting, this child suddenly showed a right hemiplegia with aphasia and marked cyanosis. Examination showed a marked systolic murmur in the second left intercostal, with marked accentuation of the second aortic, and clubbed fingers. The diagnosis made was of congenital heart lesion, pulmonary stenosis, patent foramen ovale, followed by hemiplegia.

Weber and Dörner report the case of a man of twenty-nine with evident pulmonary stenosis. As a result of a careful series of studies of the blood picture, they believe that in this case (and in all probability in other similar cases) there is really an increased blood production. In these cases with marked cyanosis and polycythemia there is thus a *plethora vera* and an increased blood production in the bone-marrow. This process is to be considered a compensatory one.

Wachenheim presented to the New York Academy of Medicine a child of six in whom a diagnosis of open interventricular septum with pulmonary stenosis had been made out. There was a loud murmur below the pulmonary site. In spite of the cardiac lesions there was no cyanosis.

In the ensuing discussion La Fetra said that he probably saw one case a month (in dispensary) of congenital cardiac lesion without cyanosis. It should be kept in mind, on the one hand, that marked congenital murmurs with no cyanosis are not at all uncommon, and, on the other hand, that there may be extreme cyanosis and clubbing of the fingers with absolutely no murmur to indicate the heart deformity. In all doubtful cases, blood examinations may be of value, since high hemoglobin and a red count of over 5,000,000 would indicate congenital heart disease. (This could not include the newly born, in whom it is well known high hemoglobin and very high red counts are the rule.—Ed.)

Graham showed a case (before the Philadelphia Pediatric Society) of a girl of five, whose heart lesion had been discovered at the age of fourteen months, during an attack of bronchitis. At nineteen months she had chicken-pox, at two and one-half years, measles, at five years, lobar pneumonia of the right lung. The heart was decidedly enlarged, the right heart being markedly enlarged. There was cyanosis only after exertion, though the child was always pale. A loud systolic murmur was heard over the entire chest. The latency of the case, the absence of cyanosis, the possibility of such a badly damaged heart withstanding both measles and pneumonia, made the case of exceptional interest.

Kohl reports a case of congenital heart anomaly. The aorta consisted of two parts, the aorta ascendens which sprang from the left ventricle, but immediately divided into three branches: the right innominate, the left carotid, and the left subclavian. The vessel, corresponding to the aorta descendens, sprang from the pulmonary aorta through the medium of the ductus Botalli. As is usual in such cases, there were other anomalies in other organs, viz.: changes in lungs, etc.

Krostein discusses the theories of the mechanism of the closure of the ductus Botalli. The view of Thomas rests upon the view that a slowing of the rate of blood-flow is concerned in the closure of the duct. After birth the pressure in the aorta becomes greater than that in the pulmonary, so that there is necessarily a slowing of the stream in the ductus. The ductus then contracts and is finally closed by proliferation (fibrotic) of its intima. In addition, Kohl believes that other factors concerned in the closure are elastic muscular fibres in the ductus intima which develop in fetal life in a symmetrical way. Furthermore, another factor is the changed position of the heart, which occurs with the first breath and which leads to a swelling of the division point of the pulmonary, thus also favoring closure of the ductus.

Bauer describes the case of a girl of thirteen who had suffered for some years with palpitation and pain in the extremities. There was pigmentation at angles of the mouth, periostitis on both tibiae, and splenic enlargement. With this there was dilatation of the left ventricle and bradycardia with increased tension. The Wassermann reaction was positive. The author classes this as a case of congenital syphilitic myocarditis and arteritis.

BOOK REVIEWS.

REMEDIAL GYMNASTICS FOR HEART AFFECTIONS.—Used at Bad-Nauheim being a Translation of "Die Gymnastik Der Herzleidenden" von Dr. Med. Julius Hofmann und Dr. Med. Ludwig Pohlman. By John George Carson, M. D., Edin., etc. Physician to the Sanatoria and Bad-Nauheim, Eversley, Hants. With fifty-one full-page illustrations and diagrams. New York: Paul B. Hoeber. 1911. Price, \$2.00.

The physical methods of treatment of affections of the heart have made such marked advances, particularly in Germany, during the last twenty years that they can no longer be regarded as the elaboration of a few enthusiasts. The relative rapidity with which these methods have come to be recognized as therapeutic measures has, no doubt, been greatly due to the existence there of natural thermal springs, highly charged with carbonic-acid gas and salines especially suitable for bath purposes in cardiac affections. The success which has attended the use of these waters as baths in conjunction with certain remedial gymnastics, selected on well-thought-out physiological grounds, has been so great as to constitute a new chapter in the practice of medicine relative to the treatment of heart affections. The greatest enthusiast of these methods would not pretend to credit them with powers, that would restore to health and strength those persons whose heart and blood-vessels are hopelessly damaged and beyond repair. But fortunately these are not the majority of the cases met with in practice. Affections of the heart, as a rule, are attended with sufficient discomfort to the patient to cause him at an early period to seek medical advice while the affection is still amenable to treatment, or at least while the condition of the patient can be materially improved. As experience has been gained in their use, the physical methods of treatment have been improved and placed upon a firmer physiological basis; their capabilities also have been more exactly ascertained and their limits of usefulness more accurately defined. In this advancement of knowledge, successive physicians at Bad-Nauheim have played so important a part that the treatment has become peculiarly associated with that health resort and with the name of the late August Schott who did so much, especially in early days, to evolve its principles and establish its practice. This edition of Dr. Hofmann's work is presented in the English language with the hope that it may be of assistance to members of the medical profession, who are desirous of making themselves acquainted with that part of the Nauheim methods of treatment of heart affections, which can be carried out in ordinary medical practice, and which, in suitable cases, gives excellent results, independently of the baths. When the latter are also available, under medical supervision, the range of usefulness of the treatment is vastly extended, and in many cases the combined treatment, sometimes in conjunction with special massage, gives the best results.

This book collates the most essential exercises for a gymnastic course without apparatus. It contains fifty-one illustrations and diagrams, giving these gymnastics in detail. Its practical value as an aid to heart therapy can only be appreciated by careful application of the principles it so thoroughly teaches.

DIE KLINIK DER TUBERKULOSE. Handbuch der gesammten Tuberkulose fuer Aerzte und Studierende. Von Dr. B. Bandelier und Dr. O. Røpke. Wuerzburg: Curt Kabitzsch (A. Stubers Verlag). 1911. Price, Mk. 9, 50.

So much has been written and is being written on tuberculosis that a work on this subject must attain special excellence to deserve more than passing notice. "Die Klinik der Tuberkulose" achieves this goal. The authors have aimed to give a complete picture of the tuberculous process as it affects the various parts of the body, embracing the anatomic, clinical, diagnostic, prognostic, therapeutic, and prophylactic considerations. This includes even tuberculosis of the eye and ear. In fact, no phase of the subject has been slighted, the aim being to produce a complete textbook on tuberculous diseases. Despite

this broad field a careful persual will show that no part of the subject has received niggardly treatment. The perfectly systematic way in which each chapter, even in its finest subdivision, is handled makes it nothing less than a pleasure to peruse. Tuberculin therapy, tuberculin diagnostic methods, the antiformin method, the laboratory detection of the tubercle bacillus, the indications for high and low altitude treatment, the prognosis in tuberculous meningitis, tuberculosis in childhood, to all of these much-discussed phases of the subject the authors bring the testimony of their own wide practical experience. It is to be expected that the work will early find a translator to place its advantages at the disposal of the English speaking profession.

THE PUBLIC HEALTH MOVEMENT. Special Volume, Annals of the American Academy of Political and Social Science, Vol. XXXVII., No. 2, March, 1911. American Academy of Political and Social Science, Philadelphia. Price: paper, \$1.00; cloth, \$1.50.

The medical profession is under substantial obligations to the Academy of Political and Social Science for its work in a number of lines which are correlated with preventive medicine. In past years, special volumes have been published on Child Labor, Race Improvement in the United States, Problems in Charities and Correction, and Public Recreation Facilities.

The present volume on the broad subject, The Public Health Movement, presents a number of essays by well-known authorities on medicine and sociology. The subject is discussed in three parts: 1. The General Problem; II. Disease Carriers—the Control of Causes; and III. Elimination of Diseases—Physical Care of Individuals.

The twenty-four essays in this volume are a valuable addition to the literature of a subject which is now engaging the attention of all physicians of broad professional interests.

THE WORK OF THE DIGESTIVE GLANDS. Lectures by Professor I. P. Pavlov, Director of the Physiological Section of the Imperial Institute of Experimental Medicine, and Professor in the Imperial Military Academy of Medicine, St. Petersburg; Foreign Associate of the Academy of Medicine, Paris; etc., etc. Translated by W. H. Thompson, Sc. D., M. D., F. R. C. S. (Eng.) Second English Edition. Illustrated. Philadelphia and London: J. B. Lippincott Company. 1910.

The work of Pavlov and his school on the physiology of digestion has revolutionized our ideas in this field. The contributions have been so numerous and important during the past few years, that few physicians, except those whose work lies chiefly along gastro-intestinal lines, have been able to keep abreast of the subject. A complete and authoritative presentation of the matter by the leading worker in this field is thus peculiarly timely. The subject is presented in the form of systematic lectures presented in a most entertaining style, so that the book is suitable, not only for reference, but for continuous reading. An adequate index and a bibliography of the most important contributions add to its value.

CLINICAL PATHOLOGY IN PRACTICE—With a Short Account of Vaccine-Therapy. By Thomas J. Horder, B.Sc., M. D., F. R. C. P., Medical Director and Demonstrator of Morbid Anatomy (Late Demonstrator of Pathology and Junior Demonstrator of Practical Medicine) at St. Bartholomew's Hospital; Physician to the Great Northern Hospital, and to the Cancer Hospital, London. New York: Oxford University Press. 1910. Price, \$3.00.

This book is typical of the English school. It does not cover any logically delimited portion of the field of medicine with German exhaustiveness, but the treatment of the subjects taken up is admirably clear and to the point. Its contents may be divided into two groups: first the collection and examination of clinical pathological material (blood-cultures, pleural puncture, lung puncture, lumbar puncture and the like); and second a discussion of vaccine therapy including the use of tuberculin. The beginner in either of these fields of work will find the directions just the practical guide he needs, and even the experienced worker will meet with many a useful hint. Whoever possesses it will find frequent occasion to refer to the book.

DISORDERS OF NUTRITION AND METABOLISM. PART IX., TECHNIQUE OF REDUCTION CURES AND GOUT. By Prof. Dr. Carl Von Noorden, Professor of the First Medical Clinic, Vienna. Edited and translated by Alfred C. Crofton, M. D., Chicago, Ill. New York: E. B. Treat & Company. 1910. Price, \$1.50.

In this volume the principles of the reduction cures are stated in a broad way without entering into minor details. A few pages are first devoted to the causes of obesity. In regard to so-called "constitutional obesity," the following is worthy of note: "Physicians are very much inclined to attribute the obesity and the lack of success in its treatment to some perversion of metabolism. The deeper, however, one attempts to gain an insight into the peculiarities of each case the more frequent will one become convinced that wrong habits of life alone generally suffice to explain the pathogenesis of obesity."

The author believes that the ideal form of exercise for these patients is mountain climbing; neither massage nor horseback riding comparing with this as an efficient means of reducing flesh.

In the consideration of the dietetics of gout, the author goes into considerably more detail. The relation of the various foods to uric-acid metabolism is discussed and several diet lists appear.

The volume of a little over 100 pages is a valuable addition to the series of which it forms a part.

CHOLERA AND ITS TREATMENT. By Leonard Rogers, M. D., F. R. C. P., F. R. C. S., B. S., I. M. S. Physician, Cholera Wards, Medical College Hospital, Calcutta, Professor of Pathology, Medical College, Calcutta, etc., etc. New York: Oxford University Press. 1911.

The author writes as one who has had long and intimate experience in the treatment of cholera. The first part of the book is devoted to a history of cholera epidemics since 1817. Chapters are devoted to etiology and prophylaxis, clinical description and morbid anatomy. In the treatment of the condition the author is convinced from his experience, that the cardinal point consists in replacing the fluids lost by the watery evacuations, and in order that this be efficient, it must be promptly carried out. This seems best done by intravenous injection of isotonic or hypertonic solution. The patients are given by mouth large quantities of calcium permanganate solution in addition. By this treatment the mortality has been reduced from 59 to 23 per cent.

STUDIES IN CARDIAC PATHOLOGY. By George William Norris, A. B., M. D. Associate in Medicine at the University of Pennsylvania; Visiting Physician to the Episcopal Hospital of Philadelphia; Fellow of the College of Physicians of Philadelphia, etc. With 85 original illustrations. Philadelphia and London: W. B. Saunders Company. 1911. Price, \$5.00.

The book is a collection of magnificently executed photographs of hearts showing various pathological changes, with an explanatory text. The specimens are from the museums of five of the most important Philadelphia hospitals, and embrace the following conditions: Acute endocarditis, chronic endocarditis, diseases of the aorta, mitral, tricuspid, and pulmonary orifices, acute pericarditis, chronic pericarditis, cardiac hypertrophy, cardiac dilatation, cardiac aneurysm, cardiac syphilis, and congenital lesions. An extensive bibliography accompanies the text.

MEDICAL DIAGNOSIS: A MANUAL FOR STUDENTS AND PRACTITIONERS. By Charles Lyman Greene, M. D., Professor of Medicine and Chief of the Department in the College of Medicine, University of Minnesota, etc., etc. Third edition, revised. Philadelphia: P. Blakiston's Son & Co. 1910.

The success with which this volume has met amply attests its worth. Without delving deeply into the technique of any one of the most complicated and less used diagnostic methods, it gives a succinct review of them all. Considerable attention is given to radiography and fluoroscopy, especially in diseases of the chest. The descriptions are clear and brief, and are greatly enhanced in value by many well-chosen diagrams. As a work, which the student may take with him to the bedside and the clinic, this seems ideal.

STUDIES IN THE PSYCHOLOGY OF SEX. By Havelock Ellis. Philadelphia: F. A. Davis Company. 1910. Price, \$3.00.

With a volume twice the size of any of the preceding ones Ellis closes this series of six volumes devoted to the most complete and thorough study of the psychology of sex. While the first five volumes presented his investigations concerning the evolution of modesty, sexual inversion, analysis of the sexual impulse, sexual selection in man, and erotic symbolism, the last volume in twelve chapters deals with the relation of sex to society. Again we are impressed by the thorough familiarity of the writer with this subject, and by the objectivity displayed in the presentation of diametrically opposed views of innumerable authors who have written on these intricate problems. No attempt can be made even to outline the variety of questions interestingly discussed in this last contribution of an author who is generally recognized as the most competent writer on this subject.

DIE PRAXIS DER ERNAHRUNGSTHERAPIE DER ZUCKERKRANKHEIT. Von Dr. Hermann Schall und Dr. August Heisler. Mit 1 Kurventafel. Wuerzburg: Curt Kabitzsch (A. Stuber's Verlag). 1910. Price, M. 1.70.

The best results in the treatment of diabetis mellitus can be obtained only by a careful study and observation of the metabolism of the individual case and an equally careful management of the diet to meet the indications as they vary from time to time. Anyone interested in this sort of work will find the concise and yet complete monograph of Schall and Heisler a useful guide. After a general consideration of the subject, a chapter is devoted to the technique of the necessary urinary examinations, another to diabetic dietary in general and in detail, a third to the practical management of diet-kitchens, and a fourth to specimen menus, that with elegance and palatability meet the various indications.

INTERNATIONAL CLINICS. A Quarterly of Illustrated Clinical Lectures and Especially Prepared Original Articles. Edited by Henry W. Cattell, A. M., M. D., Philadelphia, U. S. A. Volume 1. Twenty-First Series, 1911. Philadelphia and London: J. B. Lippincott Company. Price, \$2.00.

This volume of the "International Clinics" in its general excellence does not fall below its predecessors. Among the contributions may be mentioned a beautifully illustrated article on pellagra by George A. Zeller, a brief account of the occurrence of icterus in tuberculosis by A. S. Warthin, and an illustrated description of mosquito work in the Canal Zone by J. A. Le Prince. In an analysis of the progress of surgery during 1910, J. C. Bloodgood makes a plea for early operation in a variety of conditions, that may well be taken to heart. The variety of the contents of the volume ensures the presence in it of something for every taste.

PHASES OF EVOLUTION AND HEREDITY. By David Berry Hart, M. D., Lecturer on Midwifery and Diseases of Women, School of the Royal Colleges, Edinburgh, etc., etc. New York: Rebman Company. Price, cloth, \$2.00.

Familiarity with the most advanced theories, and positive knowledge concerning evolution and heredity have become indispensable to the practitioner who wishes to understand and to appreciate some of the most notable late contributions to pathology, to the etiology of certain diseases, and their rational and specific therapy. To our best knowledge there is no other English book extant which could, with better advantage, be used for the purpose of acquiring this essential information concerning evolution and heredity in their relations to disease.

A HANDBOOK OF OBSTETRIC NURSING—For Nurses, Students and Mothers. Comprising the Course of Instruction in Obstetric Nursing Given to the Pupils of the Training School for Nurses Connected With the Woman's Hospital, Philadelphia. By Anna M. Fullerton, M. D. Seventh Revised Edition, Illustrated. Philadelphia: P. Blakiston's Son & Co. 1911. Price, \$1.00.

Slight modifications from the former edition once more bring this useful little volume abreast with most modern obstetrical teaching.